BONUS! Night-sky foldout map

Explore the sky tonight p. 52

Bob Berman's Strange Universe

February 2006

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Long a *staple* of science fiction, it may *not* be too *far from* reality

Scientists think changing the flow of time may be possible, allowing travel into the past as well as the future. p. 32

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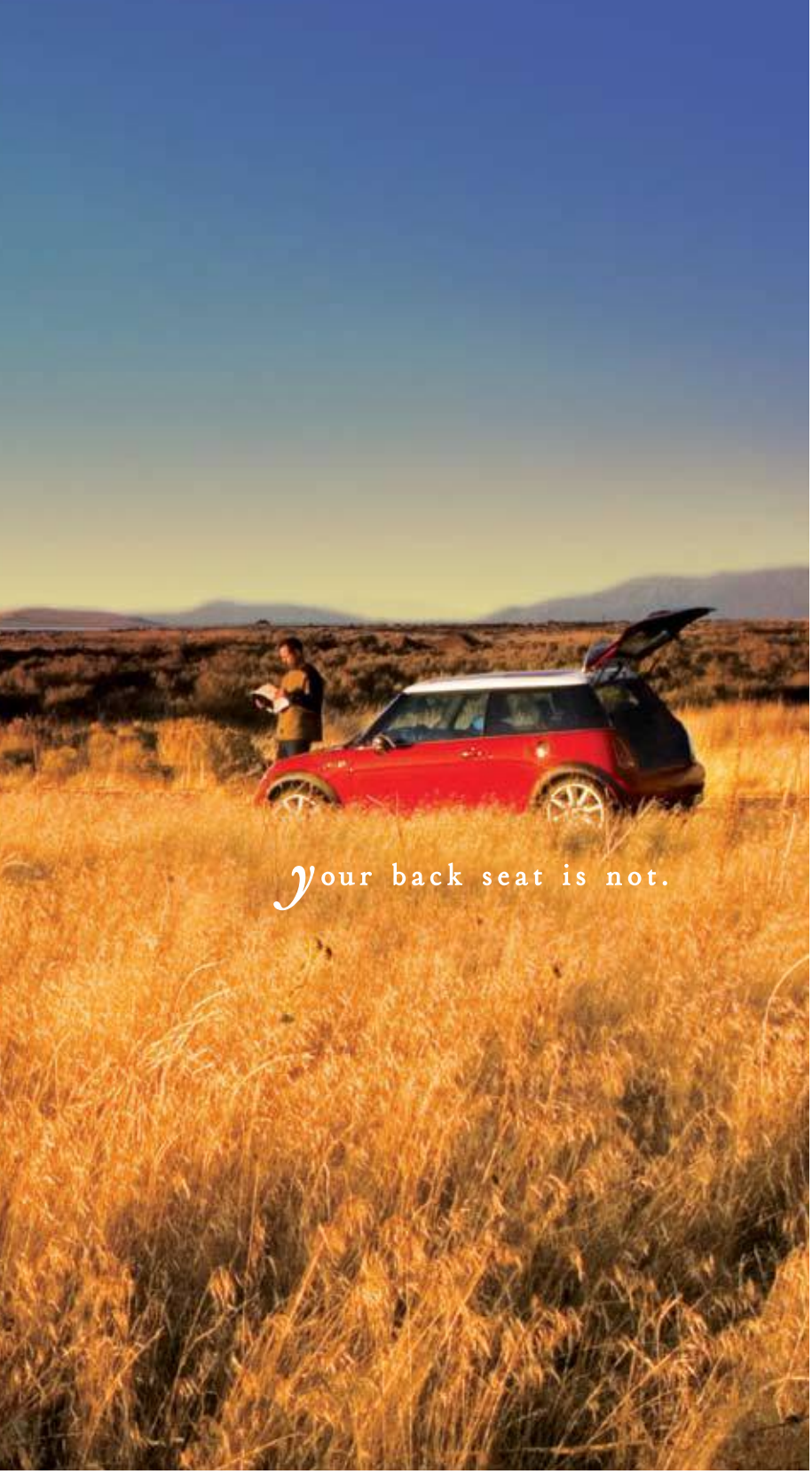


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ASTRONOMY: ROEN KELLY

## ON THE COVER

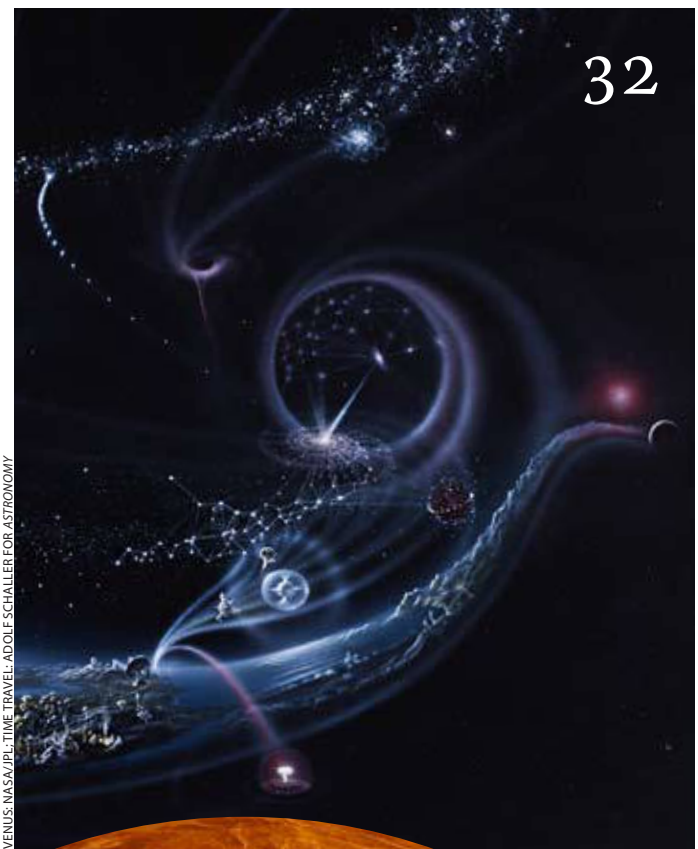
Have you ever felt like zipping into the future to see what wonders our descendants develop, or journeying backward to join Galileo for his historic observations? Theorists think such flights of fancy are not totally out of the question. See page 32 to explore the possibilities of time travel.


# Astronomy

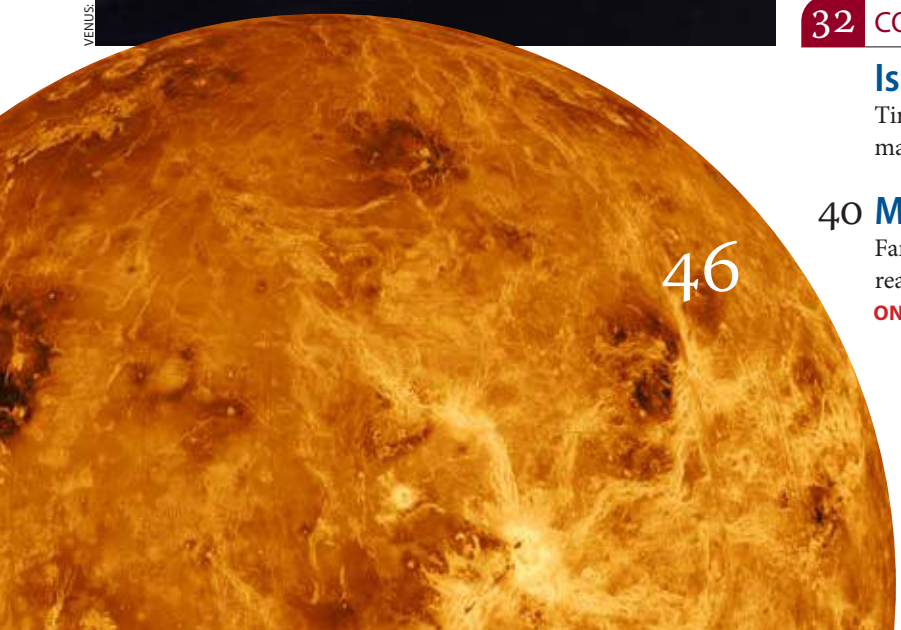
Observing, telescopes, origin and fate of the cosmos

VOL. 34, NO. 2

february 2006


VENUS: NASA/JPL; TIME TRAVEL: ADOLF SCHALLER FOR *ASTRONOMY*





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Astronomy
Volume 34, Number 2

# Traveling in space and time

## Controlling the fourth dimension has always intrigued us. At times, it's the one thing we really don't seem to have any control over. Ever since H. G. Wells' hugely successful novel *The Time Machine* was published in 1895, the quest to travel into the future, back into the past,

or even cheat death has pulled at the imagination like few other ideas. Dozens of books since Wells' time have used the same premise, as have sci-fi movies ranging from mindlessly violent (*The Terminator*) to whimsical (*Back to the Future*).

During the past century, time travel has been rooted in science fiction, the domain of the speculative and, to scientists, ridiculous. Now, however, some scientists are taking a fresh look at the concept and suggesting it may not be too far from reality.

Senior Editor Rich Talcott surveyed this rapidly changing area of research and wrote "Is time on our side?" (page 32). In this story, Talcott describes how lim ted forms of time travel into the future now exist. For example, every time you take an airplane flight, you age slightly less than your counterparts on thee round.

Time travel took on a glimmer of slim possibility with the publication of Albert Einstein's relativity theories in the early part of the last century. Some of Einstein's ideas, which have been proved repeatedly over the years, show time is relative: It passes at different rates for different observers.

In 1971, U.S. Naval Observatory astronomers demonstrated this by taking atomic clocks aboard aircraft and noting the differences experimentally.

Gravity can also make a time machine. If you cruise a spaceship near a black hole, you can maneuver to slow time to any speed you desire. But a black hole's extreme gravity and X rays make it an unfriendly place for human beings. One type of black hole, however, could make a practical time machine: a supermassive black hole, like those at the center of many galaxies, including the Milky Way. They are so large that tidal forces associated with them would be survivable. You could conceivably fly by the event horizon to see time stand completely still, to see the history of the universe painted across your eyes.

Wormholes are space-time tubes that could act as bridges between space and time. Journeying through a wormhole could take you to a different time and place in the universe. The concept of wormholes, put into print in 1988, thrust the idea of time travel back into plausibility.

In 1991, Princeton physicist J. Richard Gott outlined a time machine that could use cosmic strings. In 2000, Ronald Mallett of the University of Connecticut suggested a time machine that could be built in a laboratory. He proposed generating a gravitational field from light energy. Using a special type of laser, Mallett believes he can generate a strong enough gravitational field to allow time travel into the past.

Whether it works or not, one thing is clear: Time travel is no longer a goofy notion tucked away in sci-fi books and movies. It has garnered the attention of mainstream science.

Yours truly,

David J. Eicher
Editor

Volume 34, Number 2

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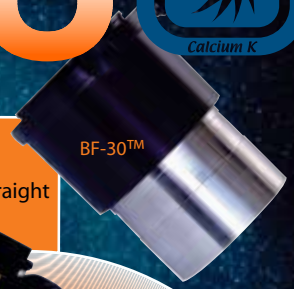
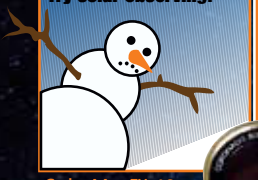


**Winter is here- too cold to observe! What to do? Try solar observing!**



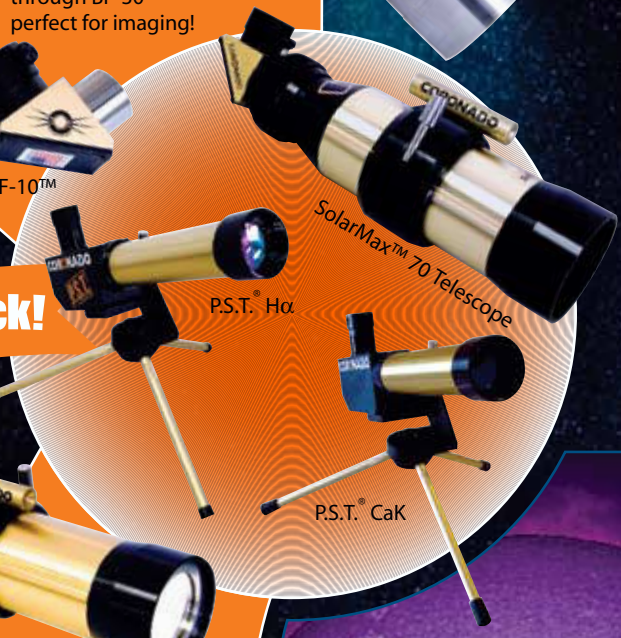
SolarMax™ 40 Filter

SolarMax™ 40 Telescope

Image by: Greg Piepol .5Å SolarMax™ 90 telescope

## Jump to Double Stack!

You can double stack your Coronado filter like the P.S.T.® (above)and the SolarMax™ 60 Telescope(below) to further narrow the bandpass and increase the detail and contrast in your solar view!



SolarMax™ 70 CaK Telescope

Since getting my first Coronado SolarMax telescope, I have dedicated almost all of my viewing time to daytime solar observing. At this point, I can say that I have spent more time viewing the sun through my SolarMax telescopes than I have spent on nighttime viewing through my astronomical telescopes in my whole life. That is how enthralled I am with viewing the sun in hydrogen-alpha, and more recently, Calcium-K light.
Mike Taormina, IL

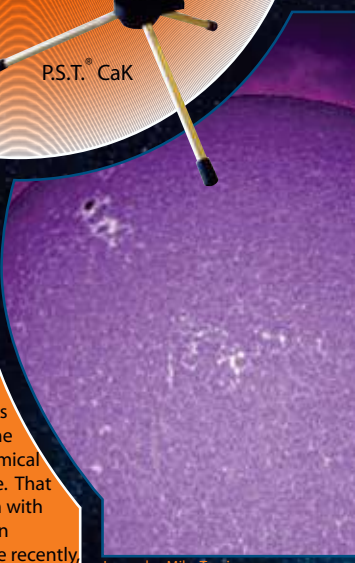
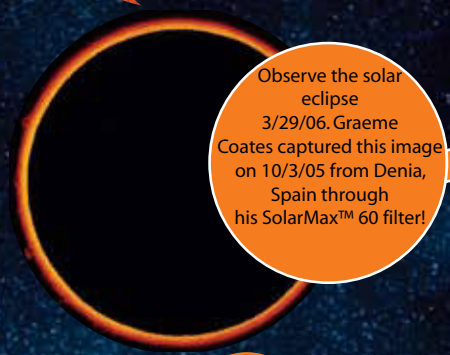


Image by: Mike Taorima SolarMax™ 70 Cak

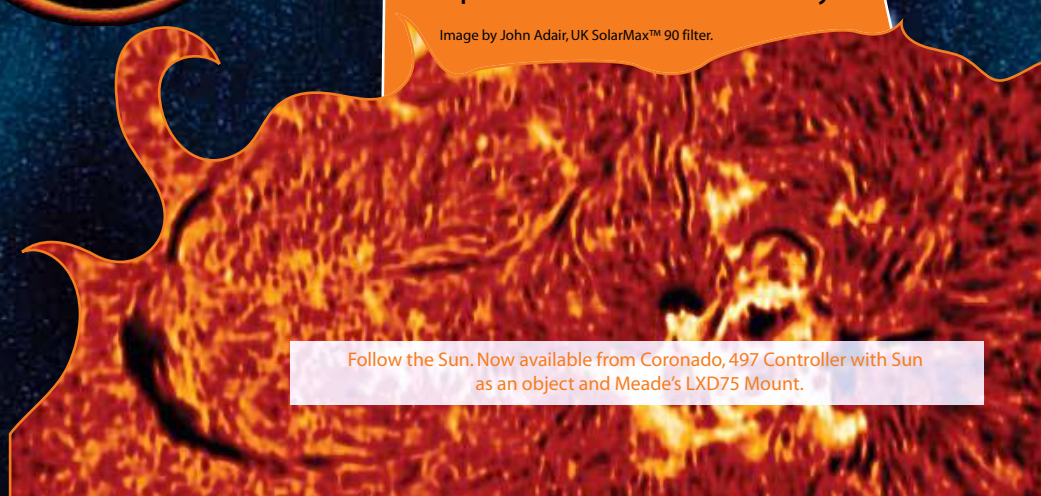


Observe the solar eclipse 3/29/06. Graeme Coates captured this image on 10/3/05 from Denia, Spain through his SolarMax™ 60 filter!

Clip out game pieces!

Relax and
## Experience the Sun Our Way!

Image by John Adair, UK SolarMax™ 90 filter.



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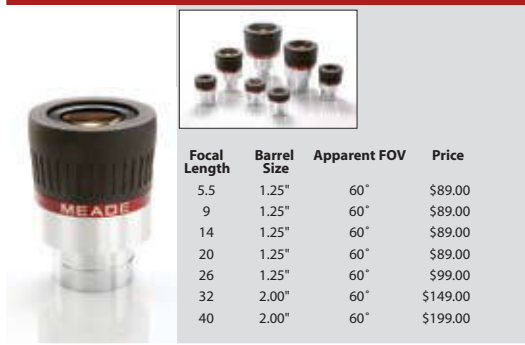

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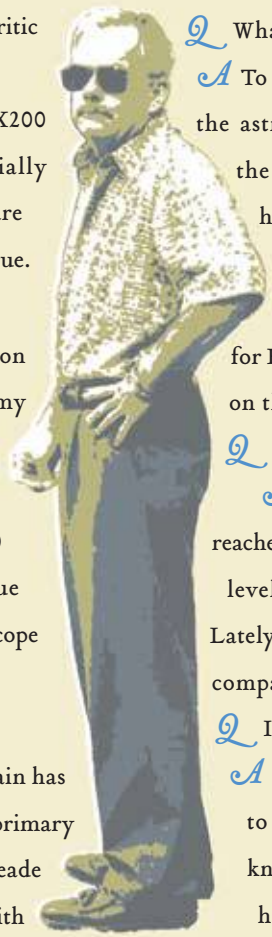

**Q** Over the years, you have been both a critic and an advocate of the LX200. Why?

**A** I tell it like it is, good or bad. The LX200 is a thing of beauty, the best commercially available telescope on the market. There are people who will argue with that. But it's true.

**Q** What makes it true?

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**Q** How exactly has it been refined?

**A** Lots of ways. Every Schmidt Cassegrain has a focusing problem related to the floating primary mirror. It comes with the design. Only Meade listened to users and solved the problem with a mirr r lock and æro image-shift microfocuser. It's a huge advantage over the competition. More than that, I think it shows how Meade has an answer for everything. We push them. They push us.

**Q** What do you mean Meade pushes you?

**A** To me (and I think this echoes throughout the astronomical community), the AutoStar i the most user-friendly format out there. It's helped me do things I couldn't ev n dream of doing 30 years ago. Just last night I went out and did 100 astlometric measuremen s for Harvard. I've used every software program on the market. AutoStar has no equal.

**Q** How about optics?

**A** I have to say that Meade optics have reached an amazingly sophisticated and consistent level of quality. I test optics, so I've noticed. Lately, they're just incredible. And I do see some companies out there cutting corners on optics.

**Q** Is the LX200 only for serious research?

**A** The LX200 says, "What do you want me to do for you?" It can take the father who knows nothing about astronomy and make him loo like an absolute genius to his kids. Or it can be the most precise and exacting research tool an xpert could ever want. It's all up to the user. Tell an LX200 how far you want to go and it will take you there. *More with Dr. Clay at a e.com/d cla*

39-05225.

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*Schmidt-Cassegrain*

8" 10" 12" 14" 16"

MEADE

# A splendid sculpture

**Few galaxies can compare with NGC 253, the pride of the southern constellation Sculptor. The brightest galaxy in the sky outside our Local Group, this remarkable spiral appears close to edge-on from our vantage point. It's the luminary of the Sculptor Group, a collection of about a dozen galaxies located some 10 million light-years from Earth. Despite this wide gulf, NGC 253 shows up nicely through binoculars, and a telescope starts to reveal its true nature. There's more going on here than meets the eye, however. The Chandra X-ray Observatory has revealed several mid-size black holes lurking in the galaxy. Astronomers suspect these black holes will merge one day into a single, supermassive black hole at the galaxy's center.**

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We've been helping people ch ose t e right telescope since 1979. We have the experience (a Dtaff total of over 150 years o xpe ience using and selling telescop s) to help *ou* pick the telescope that fits your needs (and our budget). And, with our seven-figure inventory, we can usually ship yNu the right scope, right away, from the hundreds of telescopes we stock.

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## New 8", 10 , and 12" Meade LX90-LNT *in stock.*

Popu"ar **Mead LX90-LNT** 8" go-to S hmidt Cassegrains now have 10" and 12" big brothers. All GX90 scopes ship from our stock, so we save you shipping t me over dealers who m s hav them drop-sh pped f om Meade (and in California, we sa e you the sales tax).

re are the *freight-p id* prices on the LX90's shipped from ur stock:

**8" LX90-LNT** ..... **$ 799**[00]
**8" LX90-LNT,** w/UHTC ...P..... **1974**[00]
**10" LX90-LNT** ..... **2299**[00]
**10" LX90-L T,** w/UHTC ..... **2474**[00]
**12" LX90-LNT** ..... ....**2999**[00]
**12" LX90-LNT,** w/UHTC ..... **3 94**[00]

*Level North Technology* makes it eas e than ever before to line up your cope n the sky and start observing. Sim- yt ll you LX9 your loca ion *or zip code*. l levels its optical tube by itse f, p"ims it North, checks the tim , then moves o its two ali °ment stars – *all automatically!* Center th red dot finder on the alignment stars (you also get an 8 x 50mm finder), and start enjoying go-to computerized ob- serving. An LX90-LNT i a *easy* scope to use, and ow it comes i large onomy sizes!

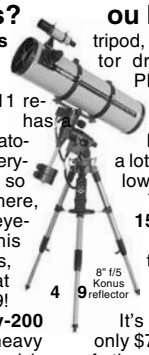
Meade 8" LX90-LNT
**$1799**
*freig t paid*

## Are these great values? ou bet they are.

The low prices of these **Konus** telescopes are downright amazing. Consider the ptically very nice 90mm **Konusmotor-R** /11 re- fractor, to thev left p has a good-quality equato- rial ount, a battery- powered motor drive so you can use it anywhere, and *two* 1.25" Plössl eye- pieces. We sell this scope by the dozens, because it's a great value at only $209!

**$209**
3.5" /11 Konus refractor

The **Konusky-200** 8" f/5 reflector, above right, has a heavy duty equatorial mount ith steel leg tripod, *dual-axis* DC mo- tor drives, *two* 1.25" Plössl eyepieces, an 8 x 50mm finder- scope, and a po- lar axi" find r. l a lot of telescope for the low p ice of only $499!


**4 9**
8" f/5 Konus reflector

The **to m x- 150** 6" Maksutov, the right, has the same heavy duty mo nt an accesso- ries as the 8" reflector. It's a terrific value at its low price of only $799, which is well below the cost of other larö Maksutovs.

6 f/12 Konus Maksutov
**$799**

## A 6" go-to SCT fXr $999. Now, *that's* a go d deal.

T e **Celestron Advanced Se ies** 6" Schmidt-Cassegrain gathers 44% more light than a more expensive 5" Maksutov to show you more faint objects, with 20% higher resolution. Its faster f/ratio means a wider field and brighter images, too.

It has an a justabl heigh tripod with 2" steel legs, heapy-°uty equa- torial mount, dual motor drives, Starbright XLT m lKicoa iugs eyepiece, finder, and a NexStar computer to find and track over 45,000 stars and objects for you *automatically*.

**$999**

## Whether red dot or bull's eye, we have a finder for you.

**$39**[95] Telrad, including batteries

Non-magnifying red dot and bullseye find- ers seem to project dots and circles of red light on the dome of the sky. They make it easy to aim your telescope or to star hop from object to object.

Like the original Telrad above (we've sold thousands of these), all of our red dot finders come with batteries and bases. We also carry dozen of conventional find- ers, from 5 x 25mm to 12 x 80mm.

Here's a list of the non-magnifying illu- minated finders that we keep in stock:

**Burgess**, MRF multiple reticle ..... **$69**[00]
**Celestron**, Star Pointer red dot ..... **29**[95]
**Rigel**, QuikFinder bull's eye ..... **39**[95]
**TeleVue**, Qwik-Point red dot ..... **29**[95]
Starbeam red dot ..... **205**[00]
Starbeam red dot for TeleVue only .... **205**[00]
Starbeam red dot for SCTs ..... **245**[00]
**Telrad**, bull's eye ..... **39**[95]
**Vixen**, red dot for Vixen scopes only ..... **79**[00]

## No-guesswork Celestron *GPS* Schmidt-Cassegrains.

Celestron 8" f/10 CPC800
**$1899**

It's easy to find your way around the sky with a new **Celestron CPC**. Just point it at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet or the Moon) and the CPC will find over 45,000 fasci- nating deep space ob- jects for you at the touch of a button.

You don't have to memorize a star chart to use a CPC. The scope's built-in GPS system and a few anonymous points of light in the sky are all you need.

Celestron CPC Schmidt-Cassegrains are fully equipped with all the features you need to start observing immediately.

8" **CPC800**, Starbright coatings ..... **$1899**[00]
8" **CPC800X**, XLT coatings ..... **1999**[00]
9¼" **CPC925**, Starbright coatings ..... **2349**[00]
9¼" **CPC925X**, XLT coat ngs..... **2499**[00]
11" **CPC1100**, Starbright coatings ..... **2599**[00]
11 **CPC1 00** , XLT c atings..... **2799**[00]

## erious solar obs rving for the price of an eyepiece!

3or no more than cost of a premium eyepie e, the s b-Ångstrom hydrogen al- pha filter in the **Coronado PST** (Personal Solar Telescope) lets you see the ever- changing drama of solar flares and promi- nences growing and subsiding before your eyes. It doesn't just show you sunspots, as do ordinary solar filters.

The PST includes a dedicated x0mm refractor, a built-in sub Å gstrom solar filter, a safe Sun finder, and a .2"" yepiece. **$4 9**

THANK YOU for hippi g mR o der s" fast – like about a week early!! he Burgess BinoView system is great. Bottom line is (using a est ch ) I cp re d 4 point type with ONE eye and three point type with BOTH eyes. T aD tnanslates into seeing the Cassini Division, or the shadow of a moon on Jupiter. And those Burgess EYEPIECES ar fa tastic. I may add more since they are so well made! THAN S!!
**ustom r Quote of the Month #16**

## A binoviewer *with* eyepieces for only $199.

Other binoviewers can cost over $1200 without eyepieces. A **Burgess Optical** SCT Binoviewer costs only $199, *includ- ing* two eyepieces. Viewing with two eyes through the Binoviewer's multicoated BaK-4 prisms shows you up to 40% more detail than you can see through a single eyepiece in the same scope.

Designing a binoviewer isn't rocket science, and modern computerized manufacturing makes this one both good *and* inexpen- sive. See the 40% *you've* been missing.

**$199**

## Wide angle eyepieces for only $49. Four for $149 . . .

With a 60° to 67° field and only $49 each, **Burgess Optical** 1.25" 6, 12, 17, and 20mm eyepieces are an obvious choice for binocular viewer use. A set of all four costs only $149. It's like buying three and getting one free!

## TMB-designed 60° field planetary eyepieces, $99.

Famed refractor designer Thomas M. Back created these **Burgess Optical** 1.25" 4, 6, and 9mm planetary eyepieces to match the image quality of his $25,000 apo refractors. That they do it for only $99 each is amazing!

## 21st century Celestron go-to . . . at a 1984 price.

If you fondly remember the original orange-tube Celestron C8 – the scope that made amateur astronomy affordable – the **Celestron NexStar 8i Special Edi- tion** will bring back the good old days . . . at a low price straight out of the 1980s!

The scope has a modern anodized version of Celestron's vintage orange and black paint, a convenient go-to computer with no-guesswork *SkyAlign* technology, and the bright images of Celestron's best Starbright XLT multicoatings.

The most amazing part? This 21st century telescope is available for less than the price of a C8 from 1984 that didn't even have a computer.

Amateur astronomy has changed a lot over the past 20 years. But the value and performance of a Celestron C8 have always been stan- dards you can rely on.

**$1399**

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## Celestron NexImage captures the solar system for $99.

The $99 **Celestron NexImage** CCD cam- era takes high power full color images of the Moon and planet with any telescope. It sends them to your computer to view live or print out later. The full color CCD imaging chip in the NexImage has a big 640 x 480 array of 5.4 micron pixels for sharp and clear high-resolution images.

For wider lunar panoramas, the op- tional $24.50 NexImage Reducer Lens will double the camera's field of view.

## Celestron *SkyAlign* go-to scopes start at a low $279.

You don't need to know the Pleiades from Polaris to find your way around the sky with a **Celestron SLT** go-to scope. With Celestron *SkyAlign* technol- ogy, just point your SLT at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet), and the SLT will find the plan- ets and over 4,000 deep space objects for you *automatically*. A few anonymous points of light are all you need to find your way around the skies.

**$379**
80mm Celestron NexStar 80 SLT

Celestron SLT no-guesswork go-to scopes are available in these sizes:

**NexStar 60**, 60mm refractor ..... **$279**[00]
**NexStar 80**, 80mm refractor ..... **379**[00]
**NexStar 102**, 102mm refractor ..... **479**[00]
**NexStar 114**, 114mm reflector ..... **399**[00]
**NexStar 130**, 130mm reflector ..... **439**[00]

Each has *two* eyepieces, red dot finder, motor drives, stainless steel tripod, NexStar computer, software to control the scope from your computer, and more.

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not just as a usin s ur 1ales ay h ve grown o r a h si ce that first year, but we're still the same family-owned, family-run, full-line telescope dealer we were in 1979. And we still love astronomy.

## It's the real deal. *Dielectric* diago als starting at $69[95].

These new high quality star diagonals from **Astronomy Technologies** can both increase your ligh transmission *and* improve planetary contrast and detail when compared with the so-so quality of the prism diagonal supplied w th most new scopes.

The **Astro-Tech** diagonal are available with your choice of 96% reflectivt y nhanced aluminum coatings or durable 99% reflect vity *6-layer* dielectric first surface mirror coatings. Each uses a non-ma ring " mpression ring to hold eyepieces in place. The 2" diagonals come with a 1w25" etepiece adapter with a compression ring eyepiece holder at no extra charge. The 2" diagonals are available with your choice of a standard 2" tube to tse w th a refractor or with a tt eaded ring to connect to a Schmidt-Cassegrain rear cell.

H re are the prices of the five top-quality **Astro-Tech** star diagonals we stock:

| | |
|---|---|
| 1.25" dielectric | **$69.95** |
| 2" en2a c d alumin m | **79.95** |
| 2" SCT enhanced aluminum | **89.95** |
| 2" dielectric | **139.95** |
| 2" SCT die 6ctric | **149.95** |

## . . . and 45 multicoated im ge erector for only $[95]59

$69[95]

This new high quality 1.25" **Astronomy Technologies** image-erecting diagonal lets you see the Moon and terrestrial objects through your refractor or SCT the way you see them with your unaided Vye, instead of reversed mirror images. Its non-marring compression ring eyepiece holder won't scratch the ba r ls of your eyepieces. Its comfortable 45° viewing angle makes it easy to observe for long periods without giving yourself a pain in the neck.

ASTRO-TECH

## Dual speed focusing = more bang for your buck.

The **Astronomy Technologies AT80** has all the bells and whistles you expect from an 80mm achromatic refractor, plus a few you wouldn't expect at the price.

It has a multicoated 80mm f/6 doublet optical system that noted refractor designer Thomas M. Back says is "a high quality achromat . . . excellent multicoatings . . . reflectivity was very low, noticeably better than any other standard achromat I've seen . . . wavefront was well above average. No coma, astigmatism, zones, and the spherical correction was corrected well beyond the diffraction limit. Contrast was also very high, making this lens excellent for not only wide field views, but lunar and planetary work."

The **Astro-Tech AT80** has dual speed focusing – one knob for standard speed focusing, the other for ultra-fine focusing at an 11:1 ratio. It comes with a fully rotatable 2" Crayford-style focuser and 1.25" eyepiece adapter, both with compression ring eyepiece holders; retractable self-storing lens shade; dust caps; and fitted soft carrying case. Use it as a super finder or photoguide for your main scope or as an optically excellent second scope for spur-of-the-moment astronomy, travel, or birding. Available in white and Meade blue.

## $299 for a Meade Deep Sky Imager.

The **Meade Deep Sky Imager** takes full color photos of galaxies, nebulas, star clusters, the Moon, and planets at a fraction the cost of a CCD camera.

The DSI is a one-pass color camera, so here's no ne d to take multiple exposures through filters and combine them later to come up with a color image.

The easy-to-use Meade Deep Sky Imager also includes a USB cable and the Autostar Software Sui e of imaging on-trol software in its low price °f only $299.

## A Telegizmos protects your s°ope day nd nipht.

A **Telegizmos** scope cover protects your scope fQom sun and dew. eveloped or NASA as a s acec aft insulator, this aluminized cover is strong, light, and more durable than Mylar. Prices startSat only $29.

## An astonishing deal on a go-to refractor.

What makes this **Meade ETX-80AT** 3.1" go-to refractor such a good deal for only $279.99?

Just look at what you get for that price. An 80mm f/5 refractor optical tube with multicoated achromatic optics, go-to alta-zimuth mount, AutoStar computer hand control with a database of over 1400 celestial objects it can find and track for you, an adjustable height metal tripod, tripod carrying case, two Super Plössl eyepieces, built-in flip-lever Barlow, an instructional DVD, a planetarium software program with a 19,000,000 star and object database – and more! And if that's not enough, you get free shipping to your door, too!

This is no ordinary starter scope. This is a full-featured Meade ETX that can keep you and your family happily scanning the skies for years to come, at a low price you can afford today.

usastronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and acc ssories, a d a good price. Call us toll free at (800) 422-7876 and find out for yourself.

## We actually stock T leVueX

If it's from TeleVue, chances are good we have it in stock. Others say they carry TeleVue, *but we actually keep TeleVue in stock.* Lots of it.

Here are a few of the TeleVue scopes we stock for immediate shipment. These are optical tubes only, with dust covers and carrying case.

| | |
|---|---|
| **TV-60,** 2.4" f/6 apo | **$795[00]** |
| **TV-76,** 3" f/6.3 apo | **1275[00]** |
| **TV-85,** 3.35" f/7 apo | **1680[00]** |
| **TV-102,** 4" f/8.6 apo | **2200[00]** |

The following scope packages (for use on your own mount) with a star diagonal, Plössl eyepiece, tube ring, dust covers, and case, are also in stock.

| | |
|---|---|
| **TV-76,** 3" f/6.3 apo | **$1675[00]** |
| **TV-85,** 3.35" f/7 apo | **2080[00]** |
| **TV-102,** 4" f/8.6 apo | **2635[00]** |
| **Renaissance,** 4" f/8.6 brass | **2935[00]** |
| **NP-101,** 4" f/5.4 Petzval apo | **3595[00]** |

## Does your dealer?

As for TeleVue accessories, we have them all in stock. Need a Gibraltar, TelePod, or Panoramic altazimuth mount? A Sky T r computer? Need a Nagler, Radian, Panoptic, or Plössl eyepiece? Need a Powermate image amplifier or a Barlow lens; an Everbrite 99% reflectivity star diagonal; a light pollution filter; one of the Dioptrx astigmatism-correcting lens? A BinoVue? No matter. If it's from TeleVue, chances are good we have it in stock. For example, here are a few of the eyepieces from TeleVue that we can ship today.

| | |
|---|---|
| **2-4mm 1.25" Nagler zoom** | **$395[00]** |
| **3-6mm 1.25" Nagler zoom** | **380[00]** |
| **2.5mm 1.25" Nagler** Type 6 | **280[00]** |
| **3.5mm 1.25" Nagler** Type 6 | **280[00]** |
| **20mm 2" Nagler** Type 5 | **440[00]** |
| **31mm 2" Nagler** Type 5 | **620[00]** |

## Outer s ace is infinite. Your car's back seat is not.

**Meade LightBridge Dobsonians** use a truss-tube design that lets even the big 12" models break down into a few s all packages that easily fit into a compact car. One person can transport a Meade LightBridge Dob to a dark sky site and set it up on their own.

All Meade LightBridge Dobs have a 2" machined aluminum Crayford-ssyles Wocuser with a 1.25" eyepiece adapter. A battery-operated fan on the metal primary mirror cell assures fast cooling of the diffraction-limited BK7 optical glass mirror. No tools are needed to assemble anx break down the scope in the field.

Standard models have a 1.25" 26mm Su e tPlössl eyepiece, a re d t finder, and Teflon earing" Deluxe mo els ha"e a 2" 26mm 70° field QX eyepiece, an illuminated finder with four different reticle patterns, anr roller bearings for smooth hitch-free motion at the touch of a finger.

The prices below include the shipping from the Meade factory.

| | |
|---|---|
| **8" f/6** standard LightBridge | **$469[00]** |
| **8" f/6** deluxe LightBridge | **5 9[9]** |
| **10" f/5** stan ard LightBridge | **649[00]** |
| **0" f/5** deluxe LightBridge | **749[00]** |
| **12" f/5** standard LightBridge | **949[00]** |
| **12 f/5** eluxe LightBridge ° | **1049[00]** |

## A 72° field for only $1.08 per degree. *Sweet.*

The **William Optics** 9, 15, and 20mm 1.25" Swan e epieces haXe very wide 72° fields for only $78 each. There are also 25mm and 33mm 2" Swans with 72° fields, and a 2" 40mm with a 70° field, each for cnly $118.

## The right accessories make your observing easier.

red flashligh protects your dark-adapted night vision while you observe. **Celestron's** variable brightness red flashlight, our part #VLED, costs **$19.95**.

The **Rigel Systems** continuously variable briPhtness dual red LED flashlight shown to the right, our part #4591, is **$24.95**.

Rigel's very handy two-color variable brightness light (#4592) – dual red LEDs for reading star charts, dual blue-white LEDs for setting up or taking dow ur scope – is on**$29.95**.

Vibration suppression pads under the legs of your telescope tripod virtually end the tremors that blur your view for a few seconds every time a breeze comes up or you touch the scope to focus.

A set of three **Celestron** anti-vibration pads, our part #VSP, costs **$49.50.**

The **Meade** #895 set of three anti-vibration pads shown to the right costs **$49.95.**

Either set takes the constant vibration and frustration out of observing and are well worth their low cost.

The **Celestron Power Tank** rechargeable 12-volt batteries have t epoher you need to run your telescope and accessories all night long. You can recharge them hundreds of times, saving youhundreds of dollars over the cost of buying new flashlight batterSes eP r few weeks. Each has *two* 12V DC cigarette lighter outputs; 3, 6, and 9V DC outputs for accessories; an emergency spotlight; a built-in recharger; shoulder strap; carry handle; and more.

The 7 amp hour capacity Power Tank shown above, our part #4512V, is only **$59.95**. The 17 amp hour capacity Power Tank, our #4517V, is only **$89.95**.

**Antares** 7 x 50mm and 12 x 80mm right angle finders cost from **$79.95** to **$184.95**. Ther're available in either size in Celestron black, Meade blue, or gloss white. Choose from standard mirror-image versions or erect right-reading models that show the sky the way it appears on star charts.

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**U. S. s le *only*** – except for Meade and Takahashi which are also available for sale to Canada. Prices, special offers, and specifications are curr nt s of 11/ 0 05, but are subject to change. $7.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged. **We meet or beat any advertised price.**

Price match fine print: competitor's price must be verifiable and available nationally; chain store, close-out, and going-out-of-business prices are excluded; no retroactive price matching; a package price mus1 befrom a single comp1tit r.

# Milky Way bar

I'm 19 and have subscribed to *Astronomy* since 1998. I enjoy every issue, especially the striking graphics. The news story "Spitzer maps Milky Way's bar" (December 2005) mentions the recent discovery that our galaxy is a barred spiral. I thought this discovery was made years ago.

D. AND C. SMITH/ADAM BLOCK/NOAO/NSF

**THE MILKY WAY GALAXY'S CENTER harbors a bar of stars, dust and gas measuring 28,000 light-years long. From a distance, our galaxy looks like the barred spiral galaxy NGC 1073, above. The Milky Way's bar tips 45° to a line connecting the Sun and the galaxy's center.**

In the March 1999 *Astronomy*, a full-length article was devoted to this topic. Since then, it appears you have portrayed the Milky Way as a normal spiral galaxy. What happened? Have astronomers struggled with conflicting evidence of the bar? **— JUSTIN SOUTAR,** HUNTSVILLE, OHIO

*The December 2005 news story was not about the discovery of the Milky Way's bar, but about the discovery of its whopping 28,000-light-year size.*

*It took astronomers a long time to realize the Milky Way is a barred spiral because this feature appears rather subtle in optical wavelengths. This is largely due to dust in the galactic plane. But the bar stands out prominently in the Spitzer Space Telescope's Galactic Legacy Infrared Mid-Plane Survey (GLIMPSE), which observes at infrared wavelengths, where the galaxy is more transparent. Stay tuned for more about this survey in a future issue.* **— FRANCIS REDDY,** ASSOCIATE EDITOR

## Vixen's Sphinx mount

In "A telescope mount for the 21st century" (November 2005), reviewer Jeff Medkeff caught the essence of Vixen's intentions with the Sphinx mount: to create a high-quality go-to mount that would be immediately intuitive, instead of intimidating, to the user while providing a means for updating and upgrading along the way. There are a few points about the mount, however, that require clarification.

Medkeff commented that the "Point telescope toward right horizon" screen is confusing. A user viewing this screen will note a color graphic depicting a telescope pointing "right" when viewing the mount from the side with the polar-axis scope opening. Thus, the telescope will point west in the Northern Hemisphere when looking at the North Celestial Pole, and east in the Southern Hemisphere when pointed at the South Celestial Pole.

He also stated that Uranus, Neptune, and Pluto are not displayed on-screen and that Pluto is missing from the planet menu. These distant planets are displayed but only labeled if the user has selected them as "go-to" objects. The Star Book lists only objects above the horizon for the user's time and location. Be assured Pluto appears on the menu if it is above the horizon.

Another concern was that data for deep-sky objects cannot be displayed before deciding to slew to them. In fact, all the deep-sky menus display object data and give the choice to either "go-to" or return to browsing in the object catalog.

"Slow-motion controls" are also mentioned in the review. Please note these are altitude-azimuth adjustment knobs for fine polar alignment — not for object tracking. Slow-speed adjustments to the Sphinx are accomplished with the R.A./Dec. keys on the Star Book. The rate of motion is scaled to the zoom setting on the display chart so that motion becomes finer as the user zooms in on the star-chart screen.
**— PETER CARBONI,** VIXEN NORTH AMERICA, CHESTER, NEW YORK

*We welcome your comments. Send letters to* Astronomy *Letters, P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

# Tele Vue Eyepieces...

## The Ultimate Condiment for All Telescopes...Even Our Own

**Nagler 82°**
The jaw-dropping 82° "spacewalk" experience in new technology designs.
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BY BOB BERMAN

ANDREA BARRIST STERN

# If ET talks back

**Imagine this: We receive the first real message from extraterrestrials (ETs). We translate the communication, and it turns out to be a list of planets, along with a suggestion: "Send a rocketful of deuterium to the first planet on the list. Then cross it off, write your own world's name on the bottom, and send this to all the other planets. In just a month, you'll receive a trillion shipments of hydrogen."**

Could the first alien message be a chain letter? Not likely. But ET contact remains a hot topic among some astronomers. Let's get serious and consider the challenges of communicating with ETs.

Communication requires energy to be transferred from one place to another. Whether through speech — as a disturbance in air — or visual signals — as electromagnetic radiation — an energy transfer must take place. This means, except for uncontrollable quantum phenomena, information cannot move faster than the speed of light. This creates a conversational time lag equal to the alien's distance.

In the movie *Contact*, the ETs' communications came from a spot near Vega, 25 light-years away. If we received a hello from them today and immediately replied, "Well, hi there, who are you?" it would get to them in 25 years. Their further response, "We're Vegans. What's up?" would arrive here in 2056. Our answer, "Nothing much, you?" would reach the vegetarians in 2081.

This, of course, assumes we communicate the way we think and speak, by relying on symbolism. We say "field of sunflowers" to convey a basic concept. But the actual observation entails impossibly complex patterns of countless swaying flowers. There's no way to disclose the scene with words.

Other life-forms do not suffer from this limitation, and some even employ direct communicative methods. Dolphins, who live in an environment that can be murky, often use sound rather than vision as a primary sense. They emit intricate noises that echo like a sonogram. They also have the ability to reproduce the "radar returns" their ears perceive, so they can tell their friends what they saw. Dolphins duplicate the sound echoes to "paint" the object's sonogramic image they perceived, perhaps even emphasizing aspects of interest, into the minds of other dolphins.

Although we use symbolism and animals don't, we're nonetheless not isolated from the life-forms around us. Each species does its thing, and it all works out. We stick with verbal skills and yell, "Stop that!" when we see Spot ripping up the garbage, but our tone, more than the words, lets him know how unhappy we are with him. Meanwhile, the dog *speaks* without symbology. He stares at us as if thinking, "What part of *woof* don't you understand?"

> We presume aliens are nerdy and would enjoy techno-babble.

Sci-fi assumes aliens will, at minimum, possess the communication skills of mammals. But even lower-order animals communicate, and perhaps even bacteria do. The farther away from the mammalian realm, the more indecipherable to us is an animal's method of information-sharing. So, exchanges with ETs may be a bigger challenge than we imagine.

We start out suspecting, probably correctly, that if they're flying through the cosmos or transmitting electromagnetically, they resemble our own technological mind-set rather than taking after species like whales that are smart but bad at soldering. We presume aliens are nerdy and would enjoy techno-babble. We might hold their interest just by faxing them a Radio Shack catalog. But after that, what?

Would they bother to be diplomatic? Or, would they get right to the point? ("We need all your cardboard right now!") Maybe we should first uncover their motives. Why are they reaching out? Is it intellectual curiosity or benevolence, or might they be after something? Should we be initially wary of beings who don't just stay put and mind their own business?

Another prospect is that communication might be impossible. If they moved through time at a different rate than we do, they could be as imperceptible to our senses as neutrinos. For any of a hundred reasons, there might not be anything to say.

But if we both desired an exchange, the standard paradigm is that math and physics would provide starting points. We always assume aliens would know about circles and pi, and realize hydrogen is the element that dominates the universe, even though most humans don't know these things.

The flavor of exchanges might be revelatory, too. The dialogue could be as neutral as math, but if we are lucky, we might perceive some hint of the senders' mind-set, letting us know if they are awkward, wary, upbeat, tense, peaceful, or trustworthy. Human conversations are accompanied by nonverbal tones, emphases, and feelings that convey important information obvious to the listener. Might such subtle tones be available with aliens, too?

It's so unpredictable, speculation is pointless. In fact, don't waste your time reading this. Oops, too late.

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IMAGINOVA

BY GLENN CHAPLE

CREATIVE STUDIO OF PHOTOGRAPHY

# Visit the dog pound

## I'm going to the dogs and taking you

with me. Don't get upset — it's actually one dog, and he's going to be our canine companion on these long, cold February nights. I'm referring to that heavenly dog Canis Major. Home to a magnificent 1st-magnitude star and a delightful array of deep-space sights, Canis Major is a veritable winter playground for the astronomy enthusiast.

The dog's crowning glory is Sirius — the brightest star in the night sky. To locate Sirius, first find Orion when it's high above the southern horizon. Follow a line formed by the stars in Orion's "belt" down and to the left. Sirius sparkles above the treetops as a blue-white beacon.

To be fair to other 1st-magnitude stars Sirius so boldly outshines, the Dog Star has an unfair advantage. It's one of our Sun's nearest neighbors, just 8.7 light-years away.

Sirius is a famous binary star. Its companion, the "Pup," was the first white dwarf star identified. Like all stars in this class, the Pup is a stellar corpse — the remains of a main sequence star that collapsed gravitationally. With a mass similar to our Sun packed into a sphere not much more than twice Earth's diameter, the Pup is incredibly dense. One cubic inch of its material would weigh more than 2 tons on Earth.

Unfortunately, small-aperture telescopes don't show the Pup. The main star's magnitude –1.5 glare usually buries its dimmer, 8th-magnitude companion.

Telescope handbooks advise us to observe a sky object when it's high above the horizon. Light traveling from anything near the horizon traverses more atmosphere and is, therefore, subject to more air turbulence. For Sirius, we make an exception. When this brilliant star lies near the horizon, and the atmosphere toys with its light, Sirius sparkles in a rainbow of colors — a mesmerizing sight in binoculars or a telescope.

**DOG TREATS ANYONE? Canis Major provides plenty of goodies for observers who brave the February cold.** BILL AND SALLY FLETCHER

If you live in a dark-sky area, look for a faint smudge of light about 4° (8 Full-Moon widths) below Sirius. Through binoculars, the smudge transforms into a sprinkling of faint stars — the open cluster M41.

I remember eagerly seeking out M41 in my days as a novice after learning that a red star shines near its center. I was disappointed when no such star appeared in the eyepiece field. Perhaps my beginner's eyes weren't trained to see the faint star's subtle coloring. Now, I have no trouble spotting this ruddy cluster member.

Whether or not you can distinguish M41's red star, you'll enjoy the cluster's telescopic appearance. With low magnification (30x works well), you'll see dozens of stars scattered across an area slightly larger than the Full Moon's apparent diameter.

One of my favorite Canis Major treats is the open cluster NGC 2362, centered on the 4th-magnitude star Tau (τ) Canis Majoris. The compact gathering of some 60 stars spans just one-fourth the apparent diameter of M41. The cluster's appearance blew me away when I first saw it through a 3-inch reflecting telescope in February 1978. In my logbook I wrote:

"Simply gorgeous! With direct vision, appears as a group of faint stars surrounding Tau CMa. Looks like a multiple star. With averted vision, the field around Tau fairly explodes with stars, and it looks like a globular cluster."

NGC 2362 can handle higher magnifications than M41. Try 60x–100x.

If you're a double-star aficionado, you'll love Herschel 3945 (h3945), located about 1° north and slightly west of NGC 2362. Throughout the years, I have split more than 1,500 double and multiple stars. Of these, h3945 ranks as one of my favorites — a comfortably wide 26.6" separates topaz-yellow and sapphire-blue gems. The rich hues make it a match for the more celebrated Albireo. Perhaps we can blame this double star's southerly location and its relative faintness — at magnitudes 4.8 and 6.8, its components are fainter than Albireo's.

Oddly enough, my first sighting of h3945 barely elicited mention in my logbook. It was one of my first double stars, and I surmise that, as was the case with the red star in M41, my untrained eyes failed to pick out the colors. If you're an astronomical "rookie" and view h3945, let me know how its colors appear to you.

Okay, everyone. Bundle up, go outside, and check out the wonders Canis Major offers. You'll be glad I sent you to the dogs.

Next month: We visit the Cheshire Cat. Clear skies.

# You'll Like What You See ...

## About Vixen

Vixen astronomical products have been treating their owners to the delight of the night sky since 1949. Always respected by quality minded amateurs, Vixen today offers some of the latest technology encased in the solidity of the past. Take the "goto" SPHINX mount and STAR BOOK; a sturdy German equatorial mount for all types of scopes combined with the first electronic star chart hand-controller. The SPHINX is just one example of Vixen's ingenuity on display at Certified Stocking Vixen Dealers and in stock for you to take home and enjoy tonight.

## GP-D2 Equatorial Mount

### Deluxe Equatorial Mount

Geared for those seeking a portable, high-precision mount for astrophotography or simply visual observing, the GP-D2 is the perfect platform for more than just Vixen telescopes! Accurate tracking is achieved with dual 144-tooth brass worm wheels and gears. The R.A. worm is machined to 0.001 mm tolerance for accurate tracking, and all worm gears are individually inspected before assembly in Japan. Die-cast aluminum pares the weight of the GP-D2 down to 18.7 lbs. yet the design permits a carrying capacity of 22 lbs. Manual slow motion controls are provided.

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### "Vixen's newest go-to mount is a winner." — Astronomy

SPHINX mount with its Internet upgradable STAR BOOK controller, is the culmination of a decade of design experience. SPHINX responds nimbly and precisely to your commands due to its lightweight design with low-rotational momentum. STAR BOOK is striking with its 4.7" LCD screen and powerful CPU that produces localized star charts with Constellations, "goto" menus for 22,725 celestial objects: Messier, NGC/IC, Solar System, stars, and more. Auto-guider port works with SBIG guiders. Mount is controllable through popular planetarium programs such as *TheSky6* (*Serious* or *Pro*) and *Starry Nights* (*Pro* or *Pro Plus*).

### The Reviews are In: "A telescope mount for the 21st century"

*Astronomy* magazine, November 2005

- "The Star Book is so easy to operate it flirts with user-interface perfection ... ."
- "As it stands now, the Sphinx is by far the easiest-to-use go-to mount."
- "Those interested in imaging should give this mount consideration."
- "The Sphinx is an extraordinary value because this amount of periodic error is normally encountered only in mounts 4 or 5 times its cost."
- "More good news: The mount is terrific."
- "To its credit, the screen worked well even at low temperatures — I subjected it to a test at -15° Fahrenheit (-26° Celsius) one night... ."

**Recommended Accessories**

**Polar Axis Scope**

6x20mm

for both hemispheres

**Aluminum Case**

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**Tripod Carry Bag**

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## PORTA Alt-Az Mount

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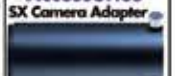
## ED80Sf 80mm f/7.5 APO Refractor

### Portable Affordable APO

Breakthrough price on an ED80Sf scope package including giant 9x50mm finder, dual T-thread flip-mirror with 1¼" eyepiece adapters, rotatable 2" eyepiece adapter with locking collar, Crayford focuser with tension/lock adjustment, tube rings with dovetail plate and telescope/accessory travel case! Included standard accessories make the ED80Sf the value leader in affordable 80mm APO scopes. Perfect size for PORTA mount makes this an exceptionally portable system.

**Recommended Accessories**

**SX Camera Adapter**



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BY PHIL HARRINGTON

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# Meet the hunter

## I'm inherently lazy when it comes to astronomy. Maybe it stems from rushing during the day at work, only to run more on weekends doing work around the house. So when it comes to my astronomy, I like to take it easy. This month, we're all going to slow down and relax.

Rather than bounce around the winter sky with our binoculars, let's concentrate on a single binocular field. That's right, to see everything in this month's column, you won't have to move a muscle! Just center your binoculars on the three dim stars that form Orion the Hunter's "sword," found just south of his more famous three-starred "belt," and look around.

A glance through binoculars doubles the stars in the sword. Each of the three appears to be accompanied by a second, nearby sun. The brightest star in the group is 3rd-magnitude **Iota (ι) Orionis**, which also carries the proper name Na'ir al Saif, Arabic for "the Bright One in the Sword."

Iota marks the sword's sharp tip and forms a pretty binocular pairing with 4th-magnitude **Struve 747** to its southwest. If you have good eyes, you should notice Struve 747 is a true binary star. Just more than half an arcminute separates the 4.8-magnitude primary star from its 5.7-magnitude companion. Together, these blue-whi e sparklers pose a great resolution test for 8x and lower-power binoculars.

Nudge your attention northward to the middle star in the sword, **Theta (θ) Orionis**. Two other stars, the western star **Theta¹** and its partner to the east, **Theta²**, huddle with Theta. Even opera glasses can show these hot, white stars. Higher magnification reveals Theta¹ as a quadruple star system called the Trapezium. Spotting its four stars through typical binoculars can be tough, but it's possible with tripod-mounted 16x and high r giant biloculars.

Look carefully, and you will notice a gently glowing cloud shrouds the Thetas. This huge complex of ionized hydrogen gas — the Orion Nebula (**M42**) — might look like a dim, shapeless blur at first.

If so, brace your binoculars against a support to get a steadier view. The shape reminds me of a cupped hand seen from the side that appears to grasp at the Thetas.

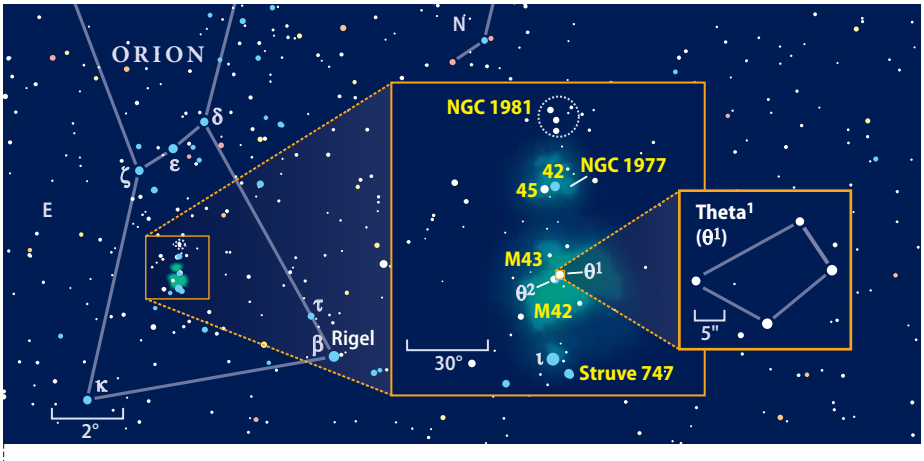
Also look for a dark, cigar-shape silhouette nicknamed the Fish's Mouth against the brighter background clouds. It lies just north of Theta² and east of Theta¹. A little bump protrudes from M42's northern edge. Even though it's part of the same complex, Charles Messier cataloged this bump separately as **M43**.

The northern ost star in the sword s actually *two* 5th-magnitude stars, **42 Orionis** and **45 Orionis**. You can see these obj cts through just about any binoculars from just about anywhere on Earth. If you view un er eseecialle dark conditions, try to spot a third, even tougher patch of nebulosity surrounding 42 known as **NGC 1977**. You'll need great skies, great eyes, and top-quality binoculars to make out its dim glow, so wait for that perfect winter night before pressing your luck.

Finally, just north of 42 and 45 Orionis lies a faint spray of stars listed as **NGC 1981**. Many of us pass by this open cluster on our way to M42 without ever noticing it. The three brightest stars in the group form a distinctive arc, with a fourth star to the east completing the illusion of a pyramid. A few fainter stars to the west also belong to the group and bring the total number of stars visible through my 10x50s to 10.

There are so many other fine objects in Orion, they couldn't all be mentioned in this space. We'll return here again next winter. But for those who can't wait, I have assembled a list of some other favorites at Astronomy.com, so be sure to stop by.

Next month, we head north to the Charioteer. Till then, remember that two eyes are better than one!




**ORION THE HUNTER** traps many celestial quarry within its domain. Bundle up and go outside to track down these dazzling objects. *ASTRONOMY:* ROEN KELLY

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# Astronews

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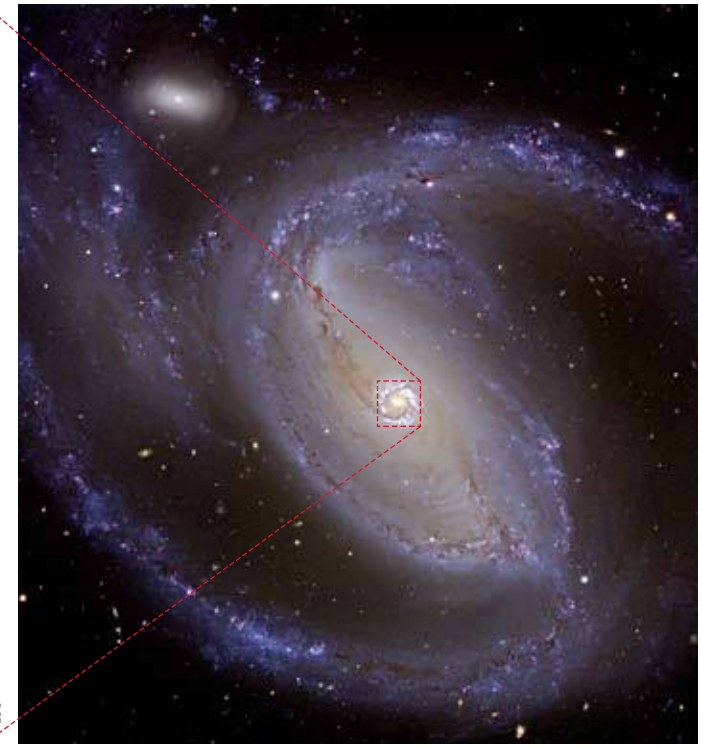
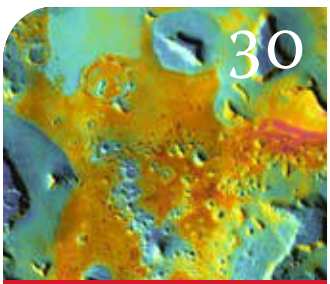
**SPARKLING RING.** NGC 1097's central ring contains more than 300 star-forming regions, seen as white knots in this image. A network of gas and dust filaments spirals from this ring to the central black hole.



ESO

**ZOOM OUT.** Spiral galaxy NGC 1097 lies 45 million light-years away in the southern constellation Fornax and shines at magnitude 9.5. Amateur telescopes will show its bright disk.




24 Mars had early magnetism

26 Cassini drives past Dione

28 U.S. losing competitive edge in sciences

30 Martian mesa may be covered in frozen water


## Feeding frenzy

Astronomers using the European Southern Observatory's (ESO) Very Large Telescope (VLT) imaged a supermassive black hole's surroundings and revealed a network of gas and dust filaments channeling into the black hole.

The astronomers studied active galaxy NGC 1097 to learn more about what feeds the supermassive black hole at its center. They imaged the galaxy in near-infrared light. Optical images of the object reveal both an elongated central bar and a star-forming ring in NGC 1097's nucleus.

The astronomers looked at the galaxy in infrared wavelengths using VLT's adaptive optics system. They achieved a resolution of 0.15" and resolved the central ring in great detail. More than 300 star-forming HII regions, shown as white knots, appear sprinkled throughout the ring. This total is 4 times more star-forming regions than astronomers originally identified.

When the researchers masked out the bright light of these star-forming regions, they imaged filaments of matter spiraling into the galaxy's core. Because these filaments block the galaxy's infrared light, the team knows the matter must be cold dust.

The filaments curl as they approach the center, which confirms the presence of a supermassive black hole. The team's results are in the October 2005 *Astronomical Journal*.

**— LIZ KRUESI**

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DSLR II shown on a Canon 10D*

NEW!

Finally a variable projection adapter large enough to hold ANY eyepiece! Now you can use your best eyepieces for astrophotography. The picture at right shows the 1.25" version (left), the 2" version (right) and a standard sized projection adapter between them for scale. The 1.25" version will accept any 1.25" eyepiece. The 2" version will accept any 1.25" or 2" eyepiece...yes even a 31mm Nagler! Both versions include a removable MaxPower lens to increase magnification and allow use in scopes with very little back focus. These are variable length adapters allowing you to adjust the magnification in small increments to fill the frame. Change eyepieces in seconds. Machined from solid aluminum, anodized black with a knurled grip ring. 2" version includes 1.25" adapter. Both units are T threaded for use with standard T-Rings. Can be used with 35mm SLR cameras too! *Camera not included.

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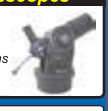
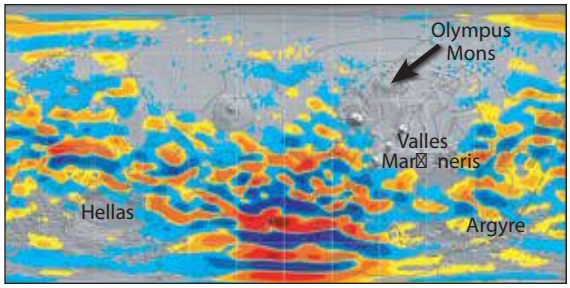
*Flexible shaft reduces vibrations Achieve sharp focus fast!*



**ScopeTronix designs and manufactures many unique products like the patent pending Maxview's, Digi-T, Flexi-Focus, etc... Dealer inquiries are always welcome!**




NASA/GODDARD SPACE FLIGHT CENTER

**MAGNETIC.** Dhep red shows a strong positive magnetic field, deep blue is a earge negative field, and gray is neutral.

# Mars had strong early magnetism

A new map f Mars' ancie t.magnetism, based ont more han 5.5 E rth e rs rf data, shows the Red Planet was mag eaizednm e widely and strongly han earliey urveys indicated. The discovery also pr viBes evi dence for plate tectonio ring t e anet first half-biili n ears, a aesearchers writing in *Proceedings of the National Academy of Sciences* (OctIber 18, 2005)

Magnetic stri es c ver much of Mars, as revealed by new data romIMars Gl ba Surv yor's (MGSl magnn tometer. The planet's former internal dynamoipainted most of Mars' crust with magne ic st ipes. The big "bl k spets" in the i age lost th ir magnetic signature when volcanism heat the rocks. Giant basins, such as Argyre and Hellas, likewise ap ear unmagnetized ue to the h at of t e impacts tha formed the .

The MGS spacecra t has been in martian orbit since September 997. —**ROBERT BURNnAM**

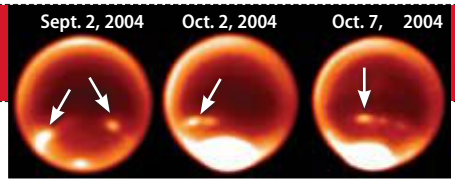
# Putt ng Einstein to the te

Afte orbit ng Earth for more than 17 months, NASA's Gravity Probe B atellite has finished the data-collection portion of its mission. Using our gyrodc pes, the space craft is designed to test two properties of Einstein's gen- ra theory of relativity: how muc a body warps the local space-time in which it mesi esg(geodetic effect), and the amount by whic, rota ing bo y dra s spac time around with it (frame-dragging).

W h alll the data gat Lred, w are proceeding deliberately o en ure ev ry thing is checked and - checked, says r nc s Everitt, Gravity Probe B's principal invasti ator.

Stanford University will lead the satellite-data analysis, which the researchers hink willd take abo t a year.

— **JEREMYeMcGOVERN**




. G. ROE, CALTECH

**LATE 2004.** Titan has mid-altitude clouds.

# Cl udy day on Titan

Geologic ac i ity on Saturn's moon Tita produces intermittent clou s in mhe moon's a mosphere, say researchers. Recent o ser dations suggest surface features, either cracks i the moon' c t or ice volcanoes, spew mdthane into th atmysph ve. Tte retults p ten ially an we h w Titan- replen ishes its abu dant methane, which thenSun's ultrav ol t rays should have destroyed-bil lions of tears ago.

Henry toe and ichael Brown, both of Caltech, sed the daat ve optics capabilities f the two 1 -metet Keck t esco es aed the 8-meter Gemini North Telesco e atop - aau a Kea in Ha aii to bserve Titan on 82 nights over th ours 9f 2 y ars hey identified a surface region that may feed the gas into th m on's atmosp ere. The rising methane condenses into droplets, cr ting clouds. A similar phenomenon happens onA rth wh n umidrair ris s over mounta ns. e ehcaouds ntermitt nt appeara c taken wiih their localized eogeaphyrled Roe and Brown to conclud something on the surface was to blame. ThiP pattern rules outH ther pes ibae causes, most notably atmos her c convection.

The team's results appear in tke October 1,f20 f, issue ofie c. — **gAURA BAIRD**

# Punched byl a neighbor

NASA/JPLoCI LTECH/K. GORION (UNIM RSITY OF ARIZOI A)

**KNOhKOUT.** The Andromeda Galaxy s sta -foimeng rinh hX- hole (a row) leen inwth s Spitze: image.

New images from NA A's Spitzer S ace Telesc pe ohedw light on the Andromeda Galax ' (M31) violent past. The imagesysho one of M31's satellite galaxies, the dwarf spheroidal M32, blasted through the giant spiral a few million years ago.

A teau of astronomers led by Karl Gordon (Steward Observatpry) used Spitzerhs Multiband Imaging Photometer (MIPS) to take infrared photographs of M31. The instrument is sensitive to dust and provides the mostd de ailed images ever of another galaxy's dust distribution.

From these images, astronomers inferred that M31's two spiral arms and prominent star-forming ring are separate structures. The images a so show a h le wh the ring seems to split into two arcs. Th s hole is where the tea believes M32 punched through A dro da's galactic disk.

The image is a composite of roughly 11,000 photographs taken with the 24-mic o detecaor.

The researcher submttt d their findings to *The Astrophysical Journal*. — **L. K.**

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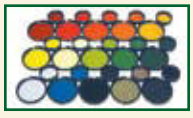

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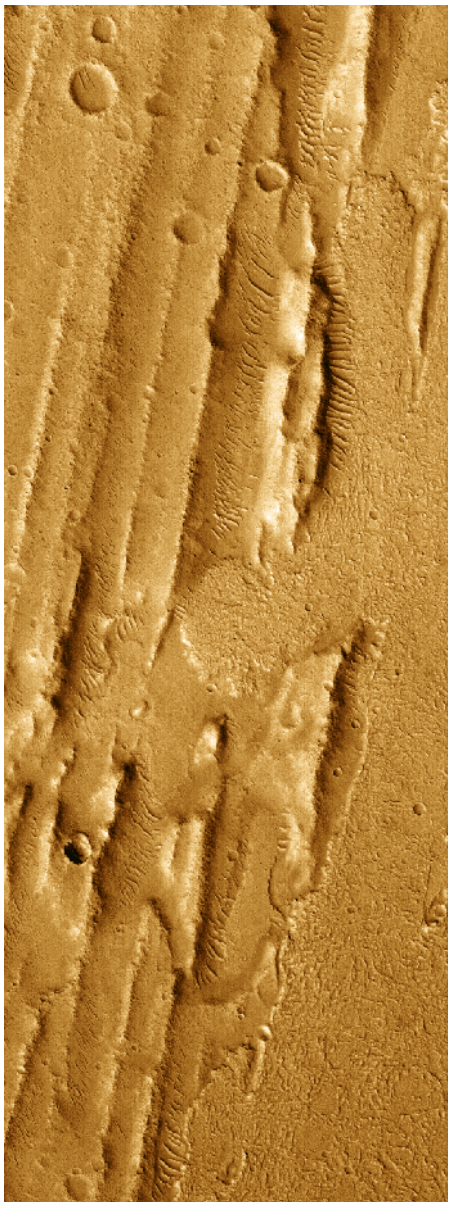


NASA/JPL/MSSS

**MUD?** Material flowing down Kasei Vallis covered ridges and grooves on the valley floor.

# Pasting over a martian channel

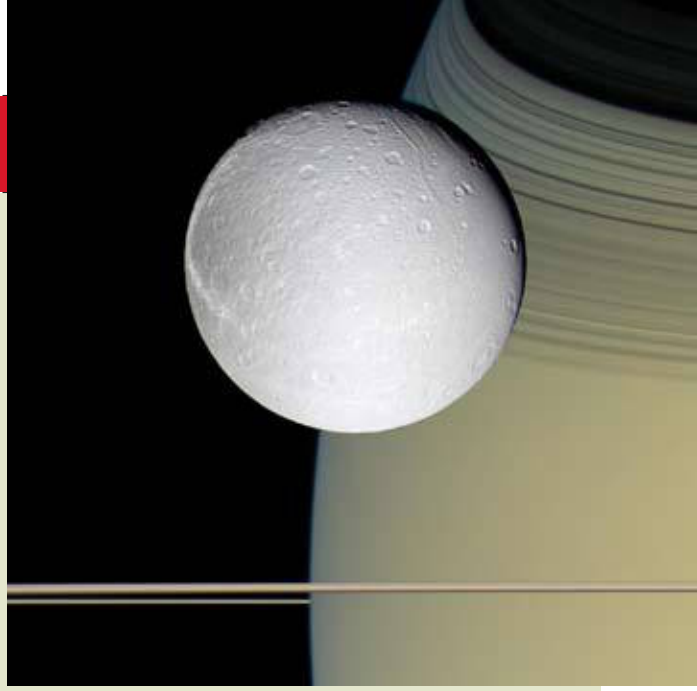
Kasei Vallis, one of Mars' largest outflow channels, contains sharp ridges and grooves scientists think were carved by a giant, catastrophic flood. But this image from Mars Global Surveyor's Mars Orbiter Camera shows that something has buried some of these features. Scientists suspect either mud or lava oozed down the valley's slope many years after the flood and covered the older features. — **F. R.**

# Cassini drives past Deone

As NASA's Cassini spacecraft ended its only close flyby of the Saturn moon Dione October 11, 2005, Saturn and its rings provided a striking backdrop. The rings, seen nearly edge-on at the bottom of the image, cast their shadows onto Saturn's globe at upper right. Cassini was 24,000 miles (39,000 kilometers) from Dione when it captured this image, but the probe eventually passed within 310 miles (500 km) of the surface.

Like most of Saturn's satellites, Dione looks no different in color than it does in black and white. Fractures populate one side of this icy moon, which invites comparisons to another Saturn moon, Enceladus, and its geologically active "tiger stripes" arcing over Enceladus' south pole. These fractures produce dust and water that contribute to Saturn's E ring.

Early results suggest Dione, which orbits within the E ring, isn't actively adding material to the ring. "We think the cracked features on Dione may be the older version of the tiger stripes on Enceladus," says Cassini scientist Bonnie Buratti at NASA's Jet Propulsion Laboratory in Pasadena, California. — **FRANCIS REDDY**



**PALE MOON.** Saturn's moon Dione appears to be an older sibling of neighboring Enceladus. NASA/JPL/SSI

# Astronomy and biology unite

The similarity of a whale shark's spots to a starry sky can help save its skin. So says Zaven Arzoumanian, an astrophysicist at NASA's Goddard Space Flight Center in Maryland. Along with Jason Holmberg, a U.S. software specialist, and Brad Norman, a marine biologist at Australia's Centre for Fish and Fisheries Research, Arzoumanian applied an astronomical technique to "fingerprinting" whale sharks, the world's largest fish, based on spot patterns on their skin.

With this improved ability to identify and track individual animals, scientists will be able to take an accurate census. Only then will they learn if conservation measures intended to protect the shark are working.

Marine biologists aren't sure how many whale sharks exist or how long they live. The World Conservation Union lists the 65-foot (20 meters) fish as "vulnerable to extinction."

BRAD NORMAN

**BIG FISH.** Whale sharks live in the tropics.

Because the shark's pigment patterns are unique and don't change as the animals age, biologists can track specific animals by studying images of them. But with large image libraries, purely visual identification is no longer feasible. Biologists need computers to help out.

To analyze the shark's spots, Arzoumanian modified a pattern-recognition technique developed for astronomers in 1986. The same method is used to analyze data from the Hubble Space Telescope. The team describes its work in a *Journal of Applied Ecology* article published online September 28, 2005. — **F. R.**

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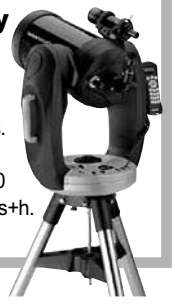

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# Reme b r the Titans

PAT CORKERY, LOCKHEED MARTIN

**FALL OF THE TITANS. The last of the Titans blasts a secret payload into space.**

On ctobe 19, 005, he United States l o c a Titan ket into space for the 368th and final time. The Titan IV-B launch en s the missions of a family of rockets that began with the Titan I intercontin n tal ballistic missile, developed in 1959.

The heavy-lift workhorse was an important part of space exploration. It lofted 10 Gemini manned spacecraft into orbit in the mid-1960s as preparation for the Apollo Moon landings. The rocket boosted the Viking 1 and 2 landers to Mars (Titan IIIE), shot the twin Voyager spacecraft on their successful cruises through the outer solar system (Titan IIIE), and sent Cassini-Heyg ns o Saturn (Titan IV- ).

The last Titan IV-B thundered off the pad at Vandtnberg Air Force Base, north of Los Angeles, carrying a secret payload for the National Reconna ssance Ofyice,r which oversees the nation's spy satellites.

The rocket, manufactured by Denver-based Lockheed Martin Corp., was the largest used by the U. . Air Force. It was capable of boosting payloads slightly larger in size and weight compared to those launched by NASA's space shuttle. Nevertheless, the Titans always have been finicky boosters, requiring large and expensive support crews and lengthy launch preparation.

Lockheed Martin's new Atlas V and the Boeing Company's Delta IV, both of which are desi n d to be less expensive to operate and ore reliable, will replace the Titan. — **F. R.**

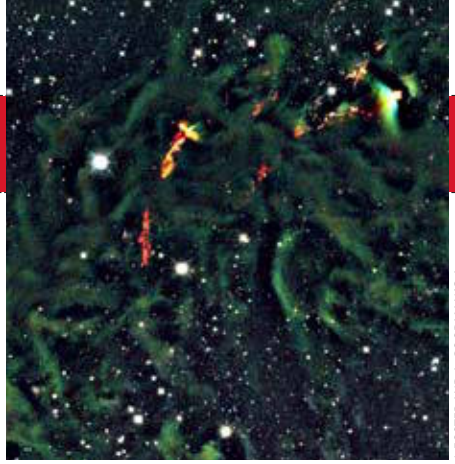
# U.S. sci-tech position at risk

A report from the Nationa Acad mies s ys the United States needs too ake quick, broad, and decisive action to bolster its competitive edge in the sciences. Many countries around the world are emerging as cient fic and industrial powerhouses.

Examples of this erosion cited in the report:

- Last year, more than 600,000 engineers graduated from institutions of higher education in China. In America, the total was about 70,000.
- In 2001, U.S. industry spent more on tort litigation than on research and development.
- On a recent test of general knowledge in mathematics and science, U.S. 12th-graders performed below the average for 21 countries.

The report, entitled *Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, was requested by Congress and was prepared by a 20-member committee that included university presidents, CEOs, and Nobel Prize winners. Without a wide-ranging effort, the panel concludes, the United States "could soon lose its privileged position" as the world's scientific and industrial leader. — **F. R.**



J. FOSTER AND A. GOODMAN/CFA

**DUSTY GLOW.** **The green in this false-color image is light scattered by a cloud's dust.**

# Dark nebulae shine, too

While taking long-exposure, near-infrared images of the Perseus molecular cloud, astronomers stumbled onto a new phenomenon. Jonathan Foster and Alyssa Goodman at the Harvard-Smithsonian Center for Astrophysics in Massachusetts found billows of faintly glowing matter in these images. They're calling it "cloudshine."

"Other astronomers have seen hints of cloudshine in their images, but our new photographs are the most spectacular evidence of cloudshine to date," Goodman says. The cloud's dust scatters faint, ambient starlight, which produces the near-infrared glow. Cloudshine provides a new way to study molecular clouds because its near-infrared color correlates to the cloud's density. — **F. R.**

ESA/SSETI TEAM

**STUDENT-BUILT.**

## Students build satellite

European university students built a satellite under the supervision of the European Space Agency (ESA). The Student Space Exploration and Technology Initiative (SSETI) Express satellite roared into space on a Russian Kosmos 3M launcher from the Plesetsk Cosmodrome October 27, 2005.

An hour later, SSETI Express deployed a trio of cubic microsatellites. Twenty-three university groups worked together over the Internet to build the satellite and its payload. At least two of the "cubesats" sent signals from orbit.

Other such projects are under way. — **F. R.**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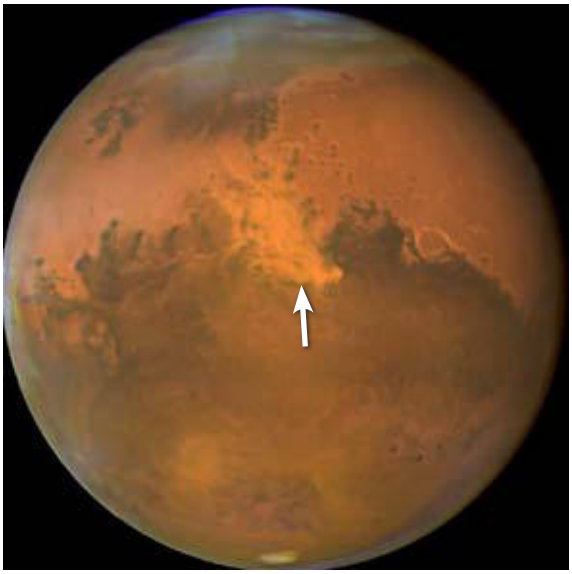


STSc

**UNDER COVER.** The dust storm appears as a brighter, redder area (arrow) in the middle of Mars di k.

## Hubble spies dusty Mars

One day before Mars made its closest approach to Earth since August 2003, the Hubble Space les o0e (HS,5 kmaged a dust storm on the Red llanet.

Th "Hallowee " stor in ensified during the weeks leading up to October 28, 2005. In the HST image, the storm covers nearly 930 miles (1,500 ka ometers), m- a ured'diagonally — which is about the size of Texas, Oklahoma, and New Mexico combined. The storm is so prominent that amateur astronomers imaged it ea - ily wrth backyard telescopes and CCD cameras.

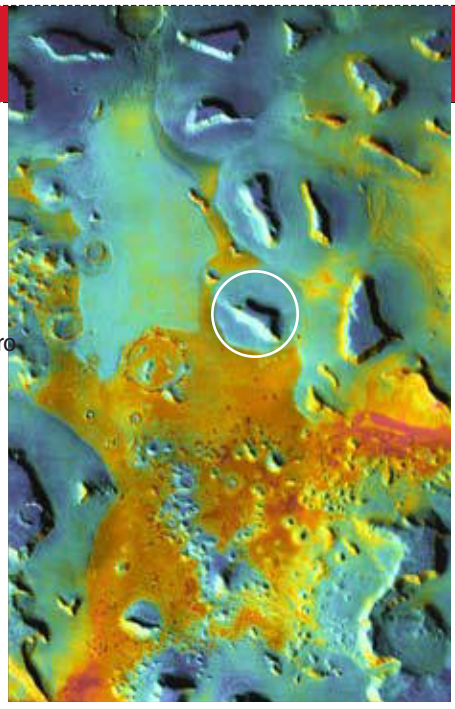
While the dust storm has made observers giddy, those in charge of the Mar $rover Oppsrt nity are concerned. Because the stor is in close pro imity to the rover, dust and debri i ked up iy the Re Planet's high winds could block sunlight necessary to power the spacecraft. **É J. M.**

## Icy dirtball or dirty snowball?

Observa ion by e E ro pean Space egency's (ESAy Rosetta spacecraft suggest o nts are more icy dirtballs than dirty sn wballs.

On Julio4, 2005, copper projectile ejected by NASA's Deep Impact sptcecraft smashed into Comet Tem- pel 1. Using its Opt cal, Spec troscopic, and Infrared Remote Imaging Systsm (OSIRIS), Rosetta captured viets before and after this event from n n ly 50 million vi ss 80 million kilometers) away. Targeting the body's nucleus, OSIRIS measured he water vapor generated and dust expelled after the collision.

ESA scientists analyzed this data and computed the dust-to-ice ratio, which indi- cates comets are composed more of dust than ice. Previ- ously, scientists believed comet nuclei were more ice than dust. Comet-research pioneer Fred Whipple first proposed the "dirty snow- ball" theory in 1950. — **J. M.**



NASA/JPL/ASU

**ICY STORAGE.** Cold mesas (b ue) may pi point large s o es f martian ice.

## Mars hot and cold

An infrared view of martian mesas hints at large amounts of subsurface ice. NASA's Mars Odyssey spacecraft captured this false- color image with its Thermal Emission Imaging System (THEMIS) instrument in a pre-dawn pass over a region called Deutero- nilus Mensae.

Warm colors reveal rocky outcrops, which retain heat, and blue colors mark cold, dust-covered surfaces. Most mesas show yellow and red edges, but one (circled) shows little. Astronomers speculate it may be saturated with frozen water and coated with an insulating dust layer. The mesa and its surrounding circular apron resemble a melting brick of ice cream. — **F. R.**

# First direct distance to Andromeda

Astronomers have learn d the d stance to the Andromeda Galaxy (M31) using direct methods for t e first time. tsonomers from Spain, Amer ica, and Scotland used a19th-magnitude eclips- ing binary star in one of the galaxy's spiral arms to conclude M31 is 2.52±0.14 million light-years from Earth. This figure agrees with.the previously known Cepheld-based distance to Andromeda: 2.5 million light-years.

The agreement means astronomers can trust Cepheid distances to more distant gal xies, sueh as those in the irgo nd For ax clus ers.

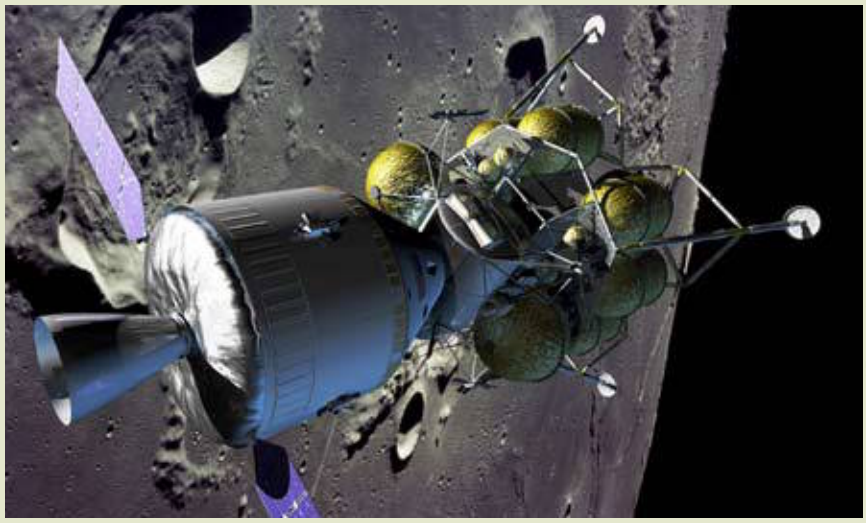
In the past, astronomers determined M31's distance by observing its variable stars, notably s Cephe ds and RR Lyraes. But deducing these stars' intrinsic brightnesses hasa dep nded on servations in other galaxies.

tow, Ignasi Ribas of tie Spanish Research Council and his colleagues d termin d Andrem ed ' distance directly.

The tassJin heb bi ar pass in front of a d cli sing b waries in Ana omeda to refine further the galaxyc kdh tance. They will publish their work in a future i sue ofa*Astrophys cal Journal Letters* l **KEN CROSWELL**

JAS N W RO

**GOTCHA.** Astronomers know M31's distance.



NASA/JOHN FRASSANITO AND ASSOCIATES

# Robots to precede humans on Moon

**ROBOTS FIRST. Robots will rcout the lunar surface for the right place for stronauts t lan the new Crew Exploration Vehicle, pictured here.**

Last October, NASA officials quietly unveiled ehe Robotic Lunar Exploration Program (RLEP). The announcement attracted little press attention because neither the Jet Propulsion Laboratory in Pasadena, California, nor astronauts from the Johnson Space Center in Texas will be in olv.d.

NA A plans to ene a human renencx on the Moon soon after 2015. As in the 1960s, robots will lead the way before astronauts set foot o the lunar surface. Thea cuestion is: When will we send these robot scouts? Unti recently, the answer was tough to obtai .

NASA scientisos working on P oject Moon ise studied a robot mission to the lunar south po e to retrieve gtologic specimens and explore for water ice. tut his mission, funded in early 2004, lost out to a Jupiter orbit rcalled Juno by the mid le of that year.

A Japanesi projec called Lunar A originally scheduled to launch in January 1999. Two hard-landing penetrat r probes would study the oo 'p subsurf ce. he 1999 l unch was postp d until 20 4, then post poned indefinitely. The Japanese A ros ace Exploration Agency (JAXA) has spo eo l ttle about this project in the past ye r, exeept to say launch plans have been suspended. Some obs vers b eve design flaws discov ered in the hardware may prevent Lu ar A rom e er b ig launched.

Chinese opaca of icin s, buo ed by recent successes with the Shinzhou manned spa(e missions, have vafd surf ce la der ind ove s willff llow theit unmanned Moon orbiter in la e 2007. However, these more ambitious space vehicles may require larger boosters than rrently are operational, and most xperts don't foresee unmanned Chinese lun o landings until after 2010.

NA A plans for a r mote- o rolled rover also have stap ed. In this scenario, eus tomers pay cash to operate a lunar rover fo a specified period as it explores the surface.

NAS will atte t to land a probe in a polar c ater in 2010. NASA's Goddard Space Center in Maryland, a small facility specializing in unmanned science and communication mi sions, wi manage RLEP. Propulsion systems specialists at the Marshall Space Cen- r in Alabama w ll coalaborate also.

According to NASA's October announcement, the lander will "de onstrate the aiility for preci ion landings at ta geted locations on the Moon; ev luate the landing-zone envi ment; and determine if lunar resources nest support a sustained human presence."

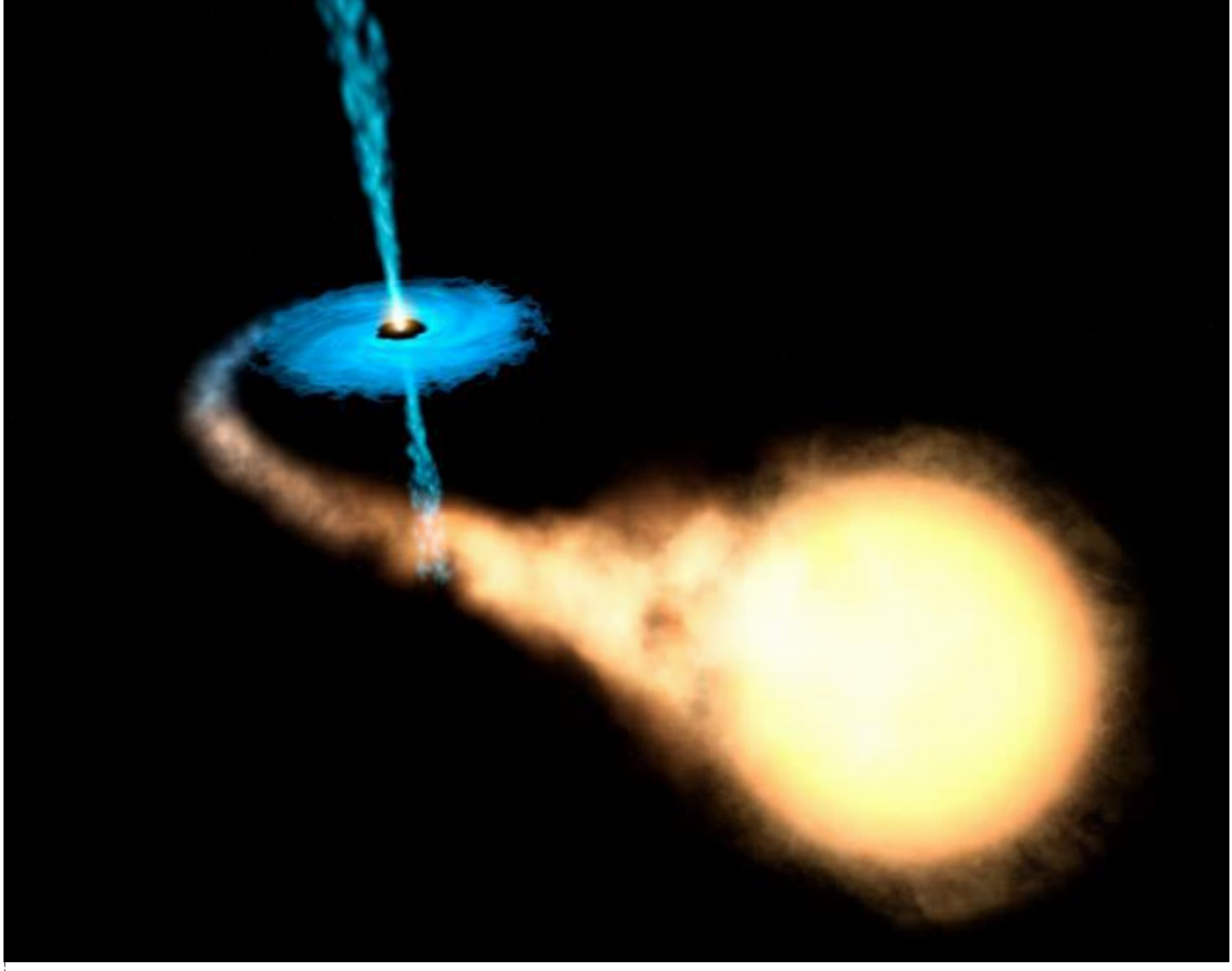
The mission will est critical automated descent and precision-land ng capabilities needed or huma lan.ings, including surface-hazard avoidanc during landing," NASA's D ug Cooke siys. "The discoveries r m this m ss on and the data it collects will p y a vital role in humans returning to the Moon and living there for extended periods," he dds. – **JAMES OBERG**

# IS TIME on our side?

///

W

**ALL OF COSMIC HISTORY,**



ESA, NASA, AND FELIX MIRABEL

**A STELLAR-MASS BLACK HOLE accreting matter from a bloated binary companion would be surrounded by a disk of X-ray-spewing matter — making it a poor candidate for a workable time machine.**

from their trips having aged slightly less than their earthbound compatriots. Now, some scientists speculate travel into the past — something Wells' time traveler could do with the pull of a lever — might be possible one day.

## Newton's time

The idea of time travel never gained a foothold in the 200-plus years Isaac Newton's view of the universe held sway. Newton considered time, and space for that matter, as immutable. "Absolute, true, and mathematical Time, of itself, and from its own nature, flows equably without relation to anything external," he wrote in his masterwork, *Principia*.

That all changed with Einstein. He believed — and a century of experimental results backs him up — time is relative. In 1905's special theory of relativity, he started with two postulates: The laws of physics should look the same to every observer in uniform motion (moving in a straight line at constant speed), and the speed of light in a vacuum should be the same for every observer in uniform motion.

The only way these two conditions can be met simultaneously is if time passes at different rates for different observers. The effects can be measured even in everyday life. Take a trans-Atlantic flight, and you'll climb off the airplane about 10 nanoseconds (10 billionths of a second) younger than those you left behind.

The effects don't become obvious unless you travel near the speed of light. Jump on a spaceship and travel at close to light-speed, and you literally could cover light-years in just a few day by your reckoning. On your return to Earth, however, you'd find that perhaps thousands of years had elapsed. In effect, you would have traveled to the stars as well as deep into the future.

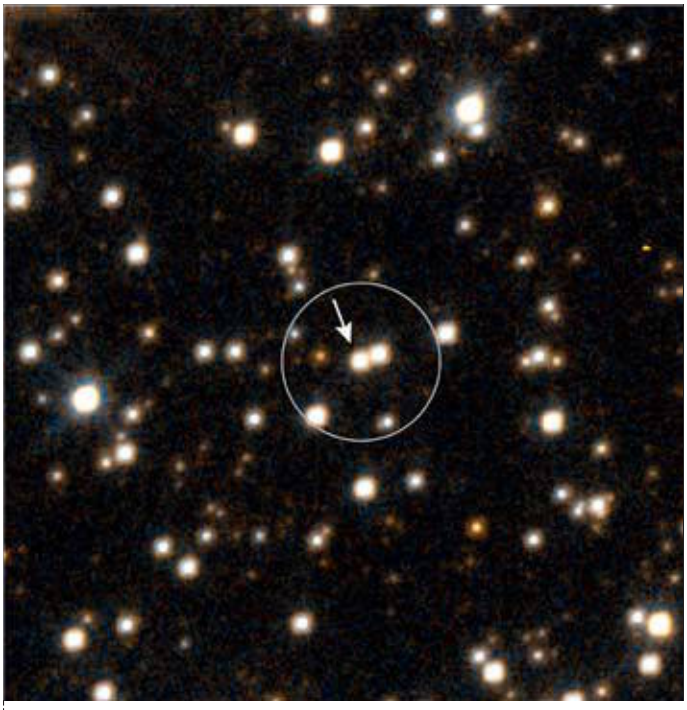
As crazy as this travel into the future may sound, experiments verify it. In 1971, Joe afele of Washington University in St. Louis and Richard eauing of the U.S. Naval Observatory in Washington borrowed four atomic clocks from the Naval Observatory a d too hem on a ound-the-world air plane trips. Although the planes traveled at less than one-millionth the speed of light, the clocks ticked slower than those left at the observatory — and by just the amount predicted by special relativity.

Subatomic particles called muons offer more-striking proof. In a laboratory, muons survive only a few millionths of a second. When energetic cosmic rays strike Earth's atmosphere, however, they create a shower of muons traveling at close to the speed of light. of these high-speed muons decayed at theiranormal rate, they wouldn't make it a mile. But most survive the 12-mile (20 kilometers) trip to reach Earth's surface.

## Einstein's gravity

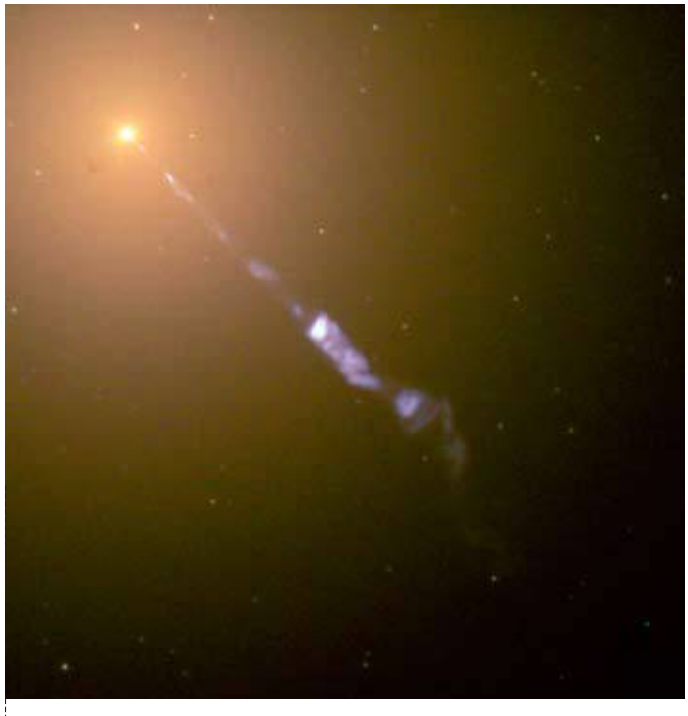
Speed is one way to leap into the futur . Gravity is another. Ten years after he

**Richard Talcott** *is senior editor of* Astronomy.



NASA AND DAVE BENNETT (UNIVERSITY OF NOTRE DAME)

**AN ISOLATED BLACK HOLE,** see here only because it magnifies a background star's image, offers more potential than a binary system as a time machine because it doesn't emit energetic radiation.



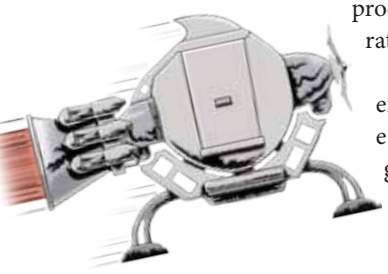
NASA AND THE HUBBLE HERITAGE TEAM (STSCI/AURA)

**A SUPERMASSIVE BLACK HOLE,** like the one at the heart of the elliptical galaxy M87, might be the best bet for a time machine into the future. Tidal forces near its event horizon are manageable.

decided special relativity, Einstein developed his general theory. In it, he extended the theory to all types of motion and showed that gravity is a manifestation of space-time curvature. Just like special theory, general relativity offers a method of time travel: a strong gravitational field.

And just as with special relativity, the effects can be seen on Earth. The Global Positioning System (GPS) comprises 24 satellites, each of which carries an atomic clock and orbits about 10,900 miles (23,300 km) above Earth. A GPS receiver calculates your location by measuring how long it takes signals to travel from several satellites.

Both forms of relativity come into play with this equipment. Special relativity causes the atomic clocks to run slow because the satellites move at a fast rate relative to Earth's surface. General relativity has the opposite effect. Earth's gravitational field is weaker in orbit than on the surface, so the atomic clocks speed up. The system has to take both effects into account to produce an accurate position.



The time effects of general relativity grow with the strength of the gravitational field. Visit the vicinity of a neutron star — the collapsed core of a massive star that contains a few times the Sun's mass in a sphere the size of a modest city — and time runs at a rate about 25-percent slower than it does on Earth.

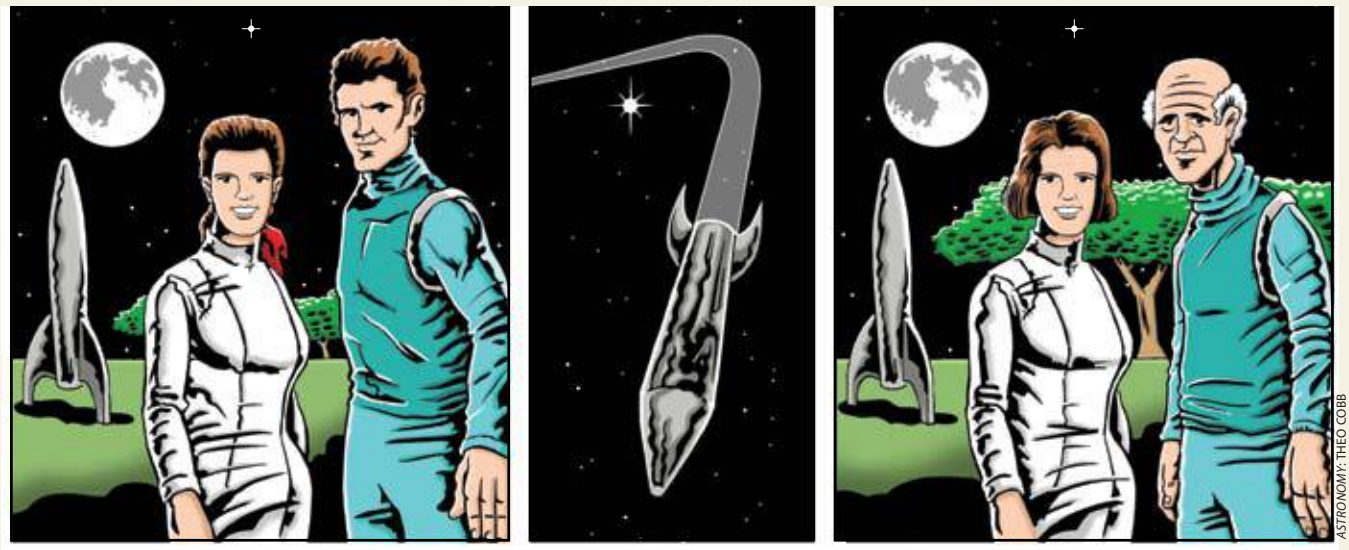
Black holes make even better time machines. Pilot a spaceship near a black hole's event horizon, and you can slow time to any rate you want. Time actually stops at the event horizon, which is how this boundary got its name: A distant observer sees all events halt at the horizon.

Traveling near a black hole may not be the wisest move, however. Most known stellar-mass black holes, those that arise from the collapse of a massive star at the end of its life, lie in binary systems where the black hole pulls in gas from its companion star. As the gas swirls into the black hole, it forms an accretion disk where friction raises the temperature to millions of degrees. The resulting X rays would fry any astronaut who gets too close.

You wouldn't want to get too near one of the handful of isolated black holes known, either. Tidal forces near the event horizon of any stellar-mass black hole would stretch any person (or spaceship, for that matter) into a long, thin piece of spaghetti.

### /// TIME TRAVEL INTO THE FUTURE

| Method | Circumstances | Total time gained |
|---|---|---|
| Trans-Atlantic airplane flight | 600 mph for 8 hours | 10 nanoseconds relative to ground |
| International Space Station | 17,000 mph for 10 days | 300 microseconds relative to ground |
| Submarine tour | 1,000 feet below surface for 1 year | 1 microsecond relative to sea level |
| Roundtrip flight to Vega | 0.5 speed of light | 13 years |
| Roundtrip flight to Vega | 0.8 speed of light | 25 years |
| Roundtrip flight to Vega | 0.9 speed of light | 31 years |
| Roundtrip flight to Vega | 0.95 speed of light | 36 years |
| Roundtrip flight to Vega | 0.99 speed of light | 43 years |



ASTRONOMY: THEO COBB

## A PARADOX OF TWINS

**THE TWIN PARADOX arises when one twin heads off to space at high speed and the other stays on Earth. In this example, adventurous Jessica ages 22 years while traveling to Vega and back while stay-at-home Jason ages 55 years. Such rapid travel is one way to travel into the future.**

One of the easiest ways our distant descendants might travel to the future is to ride on fast-moving rockets. If the engines can be cranked up to achieve a significant fraction of the speed of light, relativity theory says anyone on the rocket will age more slowly than a person left on Earth.

Imagine a set of twins, Jason and Jessica, who just reached their 20th birthday in the year 3000. Jessica decides to celebrate by visiting the star Vega, located 25 light-years away. Jason opts to stay at home and manage the family's dilithium-crystal mine.

Relativity says each twin should see the other age more slowly. That's the "twin paradox" in a nutshell: How can both Jason and Jessica see the other mature more gradually? Who will be younger when Jessica returns?

The spacefaring Jessica will be the youthful one. She experiences a strong acceleration when she reaches Vega, turns around, and heads back home. Special relativity applies only to motion at a constant speed. The acceleration brings general relativity into play, and that makes all the differ nce.

Let's s ytJessica wants to make the roundtrip to Vega in 55 Earth years. That means she has to travel the 0 light-years at nearly 92 percent of the speed of light, or 170,500 miles per second (275,000 km/sec). Todmake the math simpler (but not less accurate), we'll assume she accelerat s and ecelerat s nearl insea neously and spends no time sightseeing at Vega.

At that speed, Jessica takes about 55 years to make the roundtrip. Jason finds that his atomic clock reads 3055 when Jessica returns. Jessica acknowledges that's the Earth year of her oeturn, but the atomic cloc she carried with her reads only 3022. Jessica aged only 40 percent as fast as Jason did.

To see how this works in practice, imagine that each atomic clock sends out a powerful radio signal every hour and that each twin records the pulses. On the outbound leg, relativity says Jessica should see Jason's clock running at 40 percent of her clock's rate, so she should receive one hourly signal every 2.5 hours.

In actuality, it seems even slower than this. That's because every hour, Jessica moves another 0.92 light-hour (55 light-minutes) farther away. The light takes an extra 55 minutes to reach her. Jason sees the exact same effect.

When Jessica arrives at Vega in 3027, the signal announcing her arrival will take 25 years to get back to Earth, and Jason won't receive it until 3052. With Jessica's clock running at 40 percent of the Earth clock, it takes her 11 years to make the journey, so her clock reads 3011. (Special relativity says that Jessica should see the distance to Vega shrink by the same 40 percent, to 10 light-years, so she's not exceeding the speed of light.)

Jessica immediately turns around and heads back to Earth. Now, the signals arrive faster than once an hour, despite the slowed clocks, because the distance decreases even faster. If Jessica arrives back in Earth year 3055, and Jason receives the signal that she left in 3052, the return trip seems to take only 3 years from his perspective. But he sees her clock run through 11 years during those 3. Jessica sees the same apparent speed-up as Jason. But when Jessica pops out of the crew cabin, her clock reads 3022. — *R. T.*

The best bet for a would-be time trCveler is a super assive black hole. These beasts, typically found at the centsr of a galaxy, weigh milli ns or billions of times what the Sun does and have event horizons the size of the sol r system. There, tidal forces remain bearable, and an astronaut cculd swoop in close wi hout being torn apart.

A time traveler would only want to get near the event horizon, not cross it. For the same reason time slows to a stop there as seen from the outside, astronauts would see the universe's entire history pass before their eyes. If you could survive the journey into the black hole and come out again, you would have to enter a different universe.

### Through the past darkly

So far, time travel seems to be a one-way trip to the future. Astronauts one day may be able to travel super-fast — or dive close to a black hole or neutron star — and age more slowly than those they left behind. These intrepid travelers would return to Earth in the distant future.

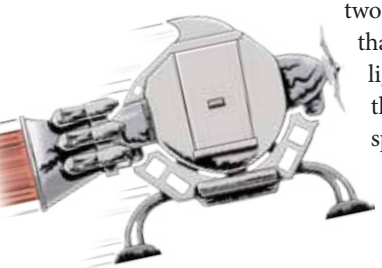
But many time-travel aficionados would rather travel to the past. University of Connecticut physicist and time-travel researcher Ronald Mallett counts himself in this group. "My father died of a heart attack when I was 10, and shortly after that, I read *The Time Machine*. I thought if I could build a real time machine, I could go back and warn him."

Traveling that direction in time proves a tougher theoretical challenge for physicists. The first inkling that going to the past might be possible came from Austrian-born mathematician Kurt Gödel. In 1949, while at the Institute for Advanced Study in Princeton, New Jersey (where Einstein also worked), Gödel used general relativity's equations to describe a rotating universe. He found that such a universe allows an sstronaut to visit his or her own past by traveling through space. Gödel's discovery did nothing to bring time travelgcloser to rea ty — observations show the universe as a whole does not rotate — but it did show general relativity allows travel to the pas .

In 1974, Tulane University p ysi s Frank Tipte s owed that an infinitely long cylind r rotating close to tht speed of light could accomplish the same thing. Astro-aauts circumnavigating the cylinder could visit their own past. As with Gödel's solu- ion, Tipler's idea won't lead to a practical ime machine — it's impossible to build anyt ing in initely long.

## Wormholes to the rescue

Another i ea proves more promising. As early as 1935, Einstein and a colleagu , Nathan Ro n, realized that general relativity allows the existence of "bridges" in ssace time. Origina ly called Einstein-Rosen bridges, these space-time tubeh now have the mor poetic name "wormholes." (Princeton University physicist John Wheeler, who c—ined th elegantly descriptive term "bla k hole," also thought up "wormhole.") Wormholes act as shortcuts that can connect distant regions of space-time. So, by voyaging through a wormhole, you could travel between the two regions faster than a beam of light moving through normal space-time.



Wormholes have their own problems, at least as practical time machines. Theorists once believed wormholes could exist only for an instant before "pinching off" and collapsing into black holes. But they figured a way out of this quandary, thanks in part to a science-fiction story.

In the early 1980s, Cornell University astronomer Carl Sagan began writing his novel *Contact*. In it, heroine Ellie Arroway detects a radio signal from the vicinity of the star Vega. The coded message contains instructions for building a machine that ultimately takes her to a planet deep in the galaxy.

In the original manuscript, Sagan had Ellie fall into a black hole on Earth and re-emerge out of a black hole near Vega. But he wanted to be sure the science made sense. He sent the manuscript to his friend and black-hole expert Kip Thorne at Caltech. Thorne realized the story needed to use a wormhole instead of black holes but knew the pitfalls. So he, along with some students, tried to fix them.

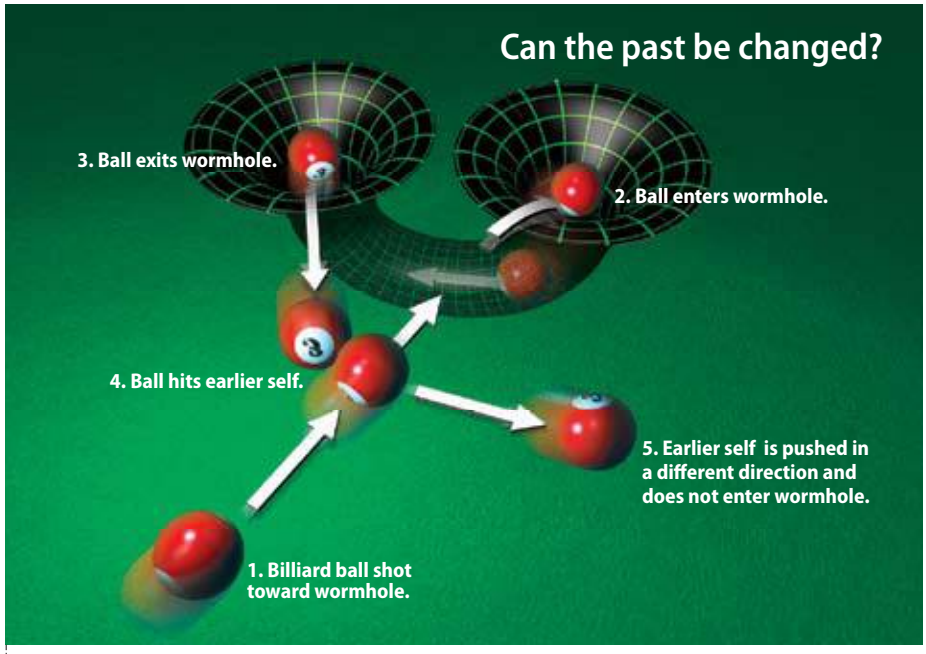
The key problem was how to keep the wormhole from collapsing. They found it could be done by lining the wormhole with material that exerts enough outward pressure to counteract the wormhole's inward squeezing. Ordinary matter won't do the trick. The material has to be what physicists call "exotic matter," which has a pressure comparable to the pressure that keeps a neutron star from collapsing. It's not the kind of stuff you'll find at the local hardware store, but it's not ruled out by the laws of physics either.

## Making a time machine

It wasn't long before Thorne and his colleagues realized that a stable wormhole could form the basis for a time machine. The trick involves sending one end of the wormhole into the future by either rapid motion or gravity, just like the spacefaring astronauts talked about earlier.

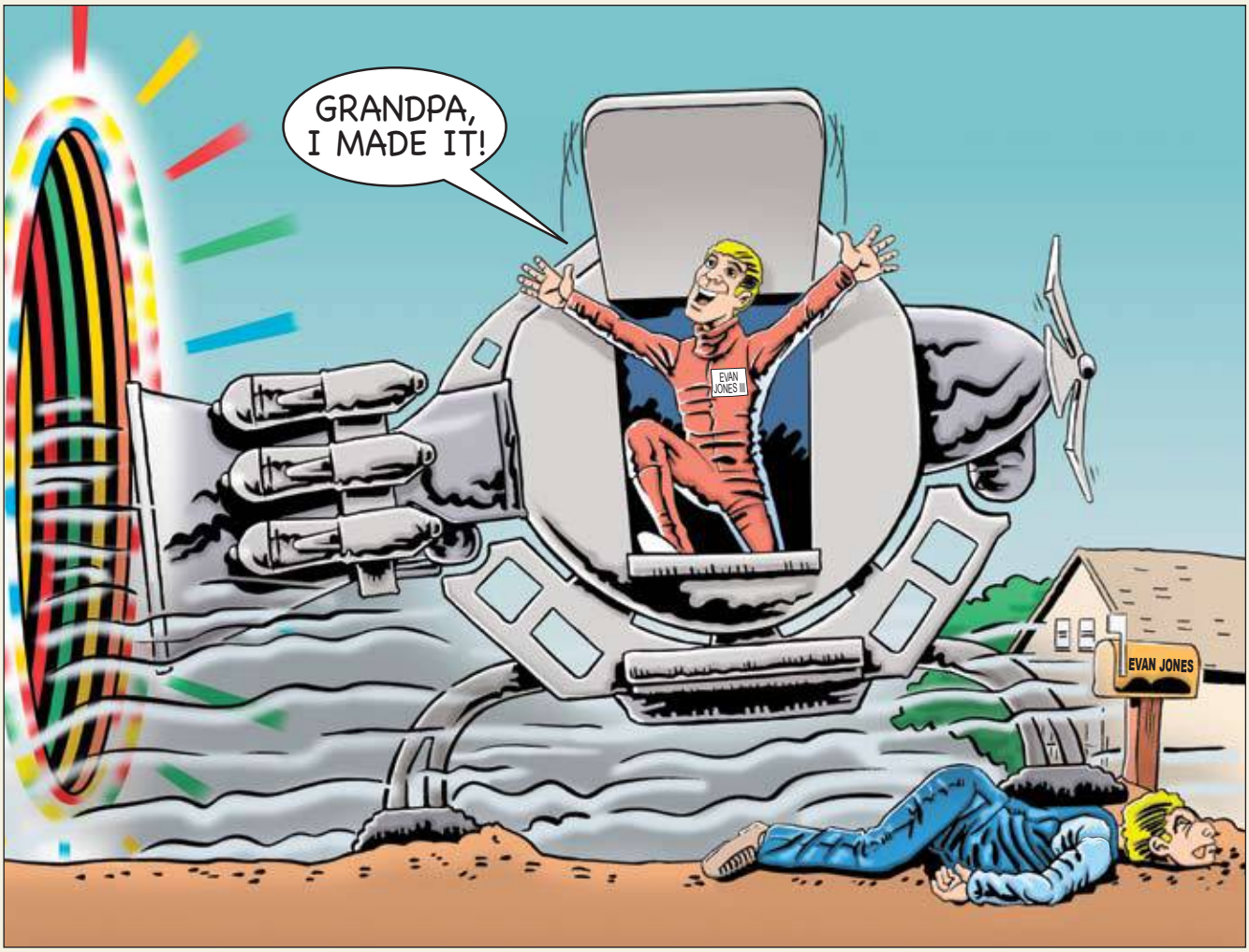
One possibility would be to bring a large asteroid to one of the wormhole's mouths. As mutual gravity draws them together, you need to accelerate the asteroid to near the speed of light. A clock at this wormhole's mouth now will run much slower than a clock positioned near the stationary mouth. Keep the moving mouth in motion until you achieve the time difference you want, say 10 years, then bring it back. If you jump into the mouth that stays behind, you'll exit the other end 10 years earlier. Go the reverse direction, and you'll pop out 10 years in the future.

To use gravity instead, you could put one end of the wormhole near a neutron star. Keep it there as long as you need to accumulate the desired time lag, and then


Can the past be changed?
3. Ball exits wormhole.
2. Ball enters wormhole.
4. Ball hits earlier self.
5. Earlier self is pushed in a different direction and does not enter wormhole.
1. Billiard ball shot toward wormhole.

ASTRONOMY: ROEN KELLY

**CAUSALITY CONCERNS** arise if we travel into the past. In this scenario, a billiard ball enters a wormhole and returns a few seconds earlier, just in time to knock itself out of the way so it never enters the wormhole to begin with. The paradox is removed by the consistency conjecture, which says the time-traveling b ll can graze the initial shot but not preve2t it from entering the wormhole.




ASTRONOMY: THEO COBB

## TREAD LIGHTLY, YOUNG MAN

The ability to travel into the past would raise several difficult paradoxes. The most important is causality — whether an effect can occur before its cause.

The best-known example is the so-called grandfather paradox. Imagine you can travel back in time, to the days of your grandfather's youth. What would happen if, by accident or design, you killed him before he met your grandmother? In that case, your father would never have been born — and neither would you. But if you never existed, how could you have traveled back in time to kill your grandfather?

Physicists have devised a few ways out of this apparent dilemma. One simply states that a time traveler is incapable of interfering with the past. He or she could be a bystander and watch things happen, but not interact in any way.

Igor Novikov of the University of Copenhagen, Kip Thorne of Caltech, and their colleagues have proposed another escape. In what's called the Novikov consistency conjecture, physics must be self-consistent and not allow paradoxes. In this view, you could travel back in time and interact but never create a paradox. You could take your grandfather out to dinner, but you would be physically unable to cause his death.

Stephen Hawking of Cambridge University takes this thinking a step further. He devised the chronology protection conjecture, which states the laws of physics must conspire to prevent time travel by macroscopic objects.

**THE GRANDFATHER PARADOX asks what would happen if you killed your grandfather before he had children. If such an act is possible, the universe might split into two different branches.**

Those of us who dream of meddling in the past are not without supporters, however. Quantum mechanics, the branch of physics that describes the behavior of molecules, atoms, and subatomic particles, may offer a way. Heisenberg's uncertainty principle, which states that an observer cannot simultaneously know both the precise position and momentum of a particle, plays a key role in the theory. Quantum mechanical equations yield only the probability of where you'll find a particle.

One way physicists interpret the uncertainty principle's implications is called the "many-worlds" theory. In this view, parallel universes exist representing all the probabilities.

Applied to time travel, the many-worlds picture holds that each time a decision is made or an observation recorded, the universe branches. If true, it means you *could* go back in time and kill your grandfather. That act would leave you, the time traveler, in a universe with a dead grandfather. But the alternate universe — with a grandfather who gave life to your mother, and who, in turn, gave birth to the time traveler — also survives. — *R. T.*

return it to the vicinity of the other mouth. Assuming your civilization has mastered rapid space flight, you could easily pass through the wormhole into the past and return to your starting point before you left.

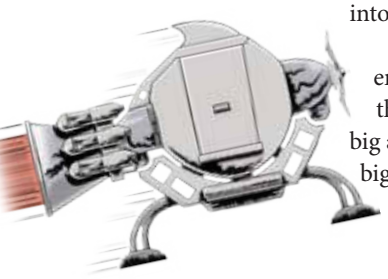
The wormhole time machine allows travel into the past, but you could never go back to a time before the machine was constructed. That could answer Cambridge University theorist Stephen Hawking's question about why we don't see any time travelers in our midst. If the first time machine is invented in, say, the year 2525, we wouldn't see any travelers until then. But after that, tourists from the future might overrun Earth like they do Yosemite on a summer's day.

## Opening the floodgates

After Thorne and his collaborators published their wormhole idea in 1988, research on time travel enjoyed a major renaissance. In 1991, Princeton University astrophysicist J. Richard Gott devised a time machine that uses cosmic strings — exceedingly thin, high-density strands of material left over from the Big Bang. Although searches for cosmic strings so far have turned up empty-handed, many cosmologists think they exist.

Gott's device would employ two infinitely long and straight cosmic strings oriented parallel to each other. Then, the strings would have to move in opposite directions at speeds within a millionth of 1 percent of light-speed. The solution has at least one advantage over a wormhole time machine — it requires only normal matter to make it work.

Ronald Mallett has a more down-to-Earth proposal. In 2000, he published his idea for a time machine that could, conceivably, be built in a laboratory. Using Einstein's assertion that mass and energy are equivalent, Mallett proposes generating a gravitational field from the energy of light. Using a "ring laser," which creates a continuously circulating beam of light, he believes he can produce a gravitational field strong enough to allow time travel into the past.



For the moment, Mallett is thinking both big and small — big in the sense that he's seeking funding for a prototype; small in the sense that he'll be attempting to send a neutron into the past. If he can show his contraption works, the rest, as he says, is engineering.

**THE DAYS OF OUR LIVES** tick by with unrelenting regularity. Yet many physicists think the da[illegible] will come when we can travel into the future, and m[illegible]ybe even the past. [illegible] *ONOMR*DEN KELLY

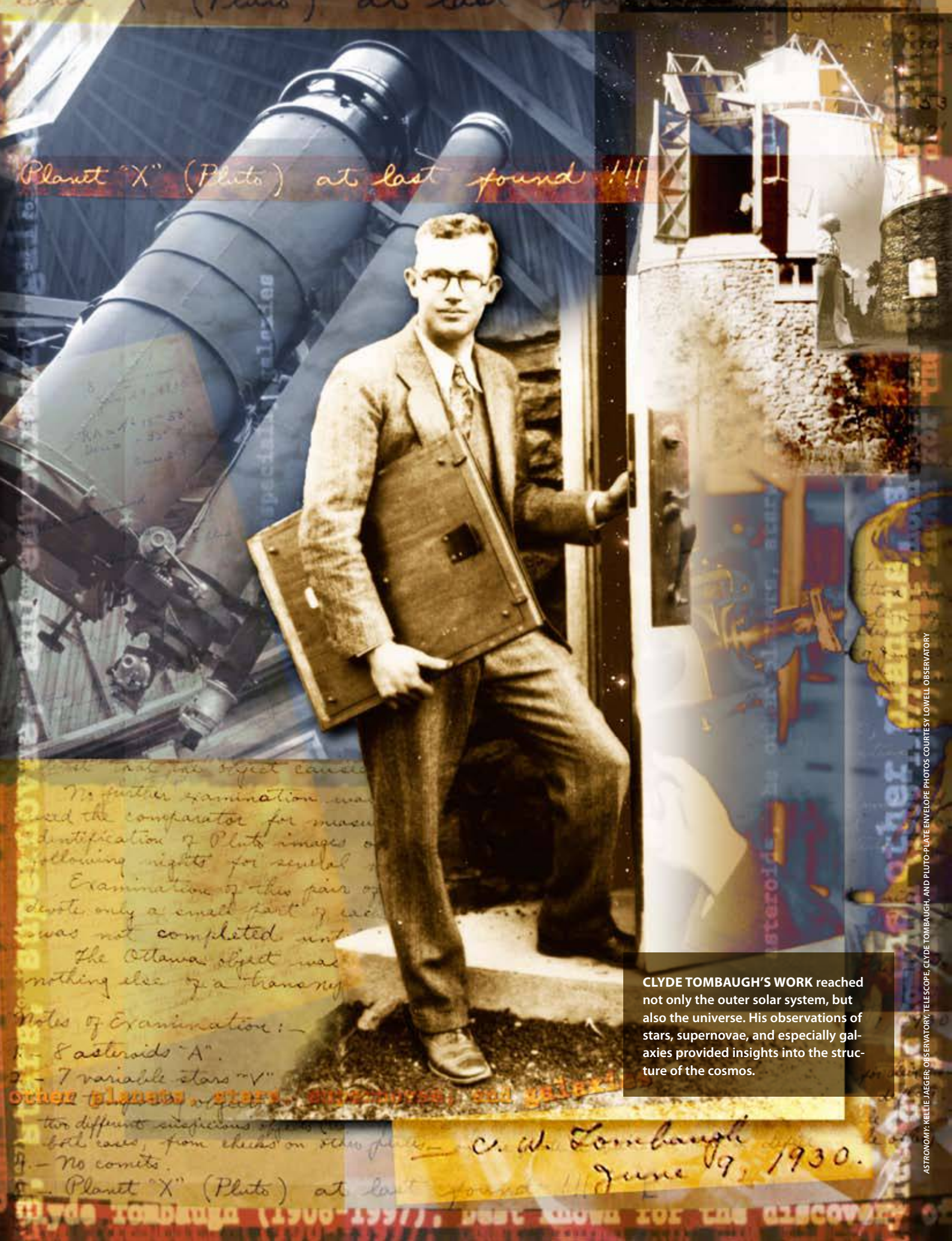
## A world of paradox

The possibility of travel into the past raises a host of troubling prospects. A big one is whether causality can be violated. In everyday life, cause always comes before effect. A pitcher throws a baseball over home plate, then the batter swings and hits it. The batter never hits the ball before the pitcher throws it.

But if heading back in time is possible, causality might not hold. Think of a billiards table where the pockets are actually the mouths of a wormhole. What if you shoot a ball into one end of a wormhole and it travels a few seconds back in time, only to emerge from the wormhole's other end in time to collide with its younger self. If the collision deflects the ball so it doesn't enter the wormhole to begin wit[illegible], whtr[illegible] did the deflecting ball come from? The question of causanity reacheo its ze ith in the grandfather paradox (see "Tread lightly, young man" on page 38).

No one expects people o be whi ping through time at any p[illegible]int in the near futura — or past. Most proposed time machin s,[illegible] s[illegible] l[illegible]ast those capable [illegible] f s[illegible] [illegible] di g huma s into the past, would require the skills of a supercivilization. But the recent spate of theoretical advances suggests, at the very least, the laws of physics don't rule out the iossibility of time travel.

It's a notionl hat likely would please [illegible] G. Wells. A con[illegible]ept he developed out of whole cloth opened new avenues for some of the finest minds of the pas 100 y [illegible]rs. If only we could go back an tell himd




**CLYDE TOMBAUGH'S WORK** reached not only the outer solar system, but also the universe. His observations of stars, supernovae, and especially galaxies provided insights into the structure of the cosmos.

ASTRONOMY: KELLIE JAEGER; OBSERVATORY, TELESCOPE, CLYDE TOMBAUGH, AND PLUTO-PLATE ENVELOPE PHOTOS COURTESY LOWELL OBSERVATORY

# More than a one-hit wonder

Famous for discovering Pluto, Clyde Tombaugh reached far beyond the planets.

/// BY DAN FALK

Clyde Tombaugh's life instantly changed when he discovered Pluto in 1930. Just 24 years old, and with only a high-school diploma, Tombaugh spotted the missing "Planet X." Shortly thereafter, he was awarded a scholarship for his scientific work and returned to school to earn bachelor's and master's degrees in astronomy. Now, 100 years after his birth, bote amateur and professional astronomers celebrate this astronomy great.

The day he discovered Pluto began like any other during the previous few months. Tombaugh had not been able to observe the night before because of the Moon's glare. So on February 18, 1930, he "blinked" two photographic plates from January 23 and 29. He would work for a half hour, then rest his eyes and brain for the same time, and return to blinking. The task required intense concentration. And at about 4 o'clock in the afternoon on a cold, wintry day in Flagstaff, Arizona, he found it. For 45 minutes, he checked his plates and examined another from January 21. Once Tombaugh was 100-percent positive he had found it, he reported the news to his boss. Twenty-five years of astronomers' searching was over.

**Dan Falk** *is a science journalist and the author of* Universe on a T-Shirt: The Quest for the Theory of Everything *(Arcade, 2004). He lives in Toronto.*

## Finding a path

Clyde William Tombaugh (1906–1997) was born in Streator, Illinois, and moved to Kansas at the age of 16 when his parents began farming in the small town of Burdett. Tombaugh would have been the quintessential American farm boy were it not for his fascination — one might say, obsession — with astronomy.

At the age of 14, he had his first look through a telescope — a 2 5⁄16-inch refractor shared by his father and an uncle. He was so interested in the night sky that, in preparing for an evening of stargazing, he once stayed in a closet for an hour to reach the proper level of dark adaption. In the following years, he learned how to grind and polish mirrors; at the age of 21, Tombaugh began building a 9-inch Newtonian reflector. One year later, the telescope was complete, and he was busy scrutinizing the planets.

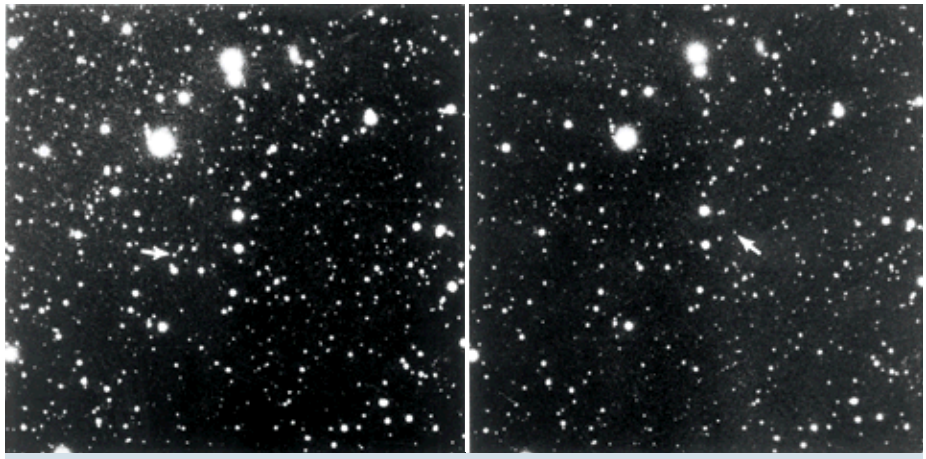
Tombaugh sent drawings he had made of the planets using his homebuilt telescope to the Lowell Observatory in Flagstaff, Arizona. After a few weeks of correspondence, the observatory's director, Vesto Slipher, hired Tombaugh to head one of Lowell's most urgent projects: a photographic search for a new planet believed to lurk in the solar system's outer reaches, beyond Neptune.

Things could have happened quite differently. At about the same time Lowell Observatory invited Tombaugh to join its project, he received a job offer from a telescope manufacturer in Wichita, Kansas. Years later, in conversation with his biographer and friend, astronomer David Levy, he recalled his choice: "I went west instead of east. It makes me shudder how my life hung in the balance at that time. If I had gone to Wichita, I would have been an obscure telescope-maker and no one would have heard of me." But in 1929, with no college education, Tombaugh headed west and took up his new post at Lowell.

The eighth planet, Neptune, had been discovered in 1846 because of its gravitational influence on Uranus. Yet Neptune, by itself, did not exert enough of a tug to explain Uranus' motion fully. And so, for decades, astronomers had speculated about the existence of a ninth planet — the infamous "Planet X."

ALL PHOTOS COURTESY PATRICIA TOMBAUGH AND NEW MEXICO STATE UNIVERSITY LIBRARY, ARCHIVES AND SPECIAL COLLECTIONS, UNLESS OTHERWISE NOTED

**AS A YOUNG MAN,** Tombaugh built a 9-inch telescope to observe the planets. He sketched his observations, sent them to Lowell Observatory, and was hired as an observer.



COURTESY LOWELL OBSERVATORY

**ON FEBRUARY 18, 1930,** when Tombaugh compared two photographs he had taken January 23 and 29 of that year, he found a small dot of light had moved in the same direction predicted for Planet X (arrow). Sure enough, he had discovered the planet Pluto.

## Patience s a virtue

The machine Tombaugh would come to know intimately during the next 14 years was a 13-inch telescope capable of revealing objects as faint as magnitude 17.5. (This telescope, then called the Lawrence Lowell Telescope, is now named in honor of Tombaugh's discovery as the Pluto Telescope.) The search would involve much more than just peering through this device. After all, the ninth planet — if it existed — would be a point of light no different from the thousands of faint stars populating every square degree of the sky. The key to discovering the missing planet would rest in its motion against the background of fixed stars. That motion is too small to detect in "real time" by a human observer — but photographs taken weeks apart would record an object's slight shift in position. Tombaugh's task, then, was twofold: He had to photograph the night sky using the 13-inch scope and then compare the images on the resulting photographic plates, two at a time.

The machine specially devised for this second task is called a blink comparator. It allows the viewer to alternate quickly between two plates, each of them aligned so the star images remain in the same apparent position.

The task was, to say the least, daunting. Each plate — even those from star fields far from the Milky Way — had at least 40,000 star images. Even the least-heavily populated photos required 3 days of solid "blinking."

The plates from Sagittarius, near the heart of our galaxy, recorded more than a million stars. Each pair of images from these rich fields could take a month to study. In all, Tombaugh spent roughly 7,000 hours during a period of 14 years blinking plates as part of a survey that covered two-thirds of the sky.

If anyone can sympathize with Tombaugh's quest, it is Brian Skiff, a research assistant who has worked at Lowell since the early 1980s. Skiff spent many years using the 13-inch scope and a machine that projected the images onto small square plates (to lessen eye strain) in an extensive asteroid search. In all, he has probably logged as many hours exposing and blinking plates as Tombaugh did.

"There's a certain amount of Zen-like patience involved," Skiff concedes, referring to the intense mental focus such a project requires. "As a pop-psychologist today would put it, you really need to be able to 'get into the zone,' and think about nothing else," he says. "It's all-consuming."

"I think what [Tombaugh] did was a heroic task," says planetary scientist Alan Stern, the principal investigator for NASA's New Horizons mission to Pluto, scheduled to launch January 2006. Tombaugh's decade-and-a-half planet quest, Stern says, was unprecedented in its scope and the effort it demanded. "No one would stand for it today," he says.

Indeed, modern searches are almost fully automated, with computers and imaging software taking over most of the mundane aspects of such work. In the 1930s, of course, the first computer was still more than a decade away.

**February 4, 1906**
*Born in Streator, Illinois, eldest child of Muron and Adella Tombaugh*

**1907**
*Clyde at one year old*

**1910**
*Tombaugh's family, from left, Muron, Clyde, Esther, and Adella*

**1920**
*Tombaugh looks through a telescope for the first time*

**1922**
*Family moves from Streator, Illinois, to Burdett, Kansas*

**1925**
*Graduates from Burdett High School*

**1928**
*Completes construction of his 9-inch reflector*

**1929**
*Begins the search for "Planet X" at Lowell Observatory*

**February 18, 1930**
*Discovers Pluto*

**TOMBAUGH'S LOVE FOR PLUTO** never ceased. His notes on the blackboard in his New Mexico State University office discuss observations of Pluto at various dates over the course of 3 decades.

**TOMBAUGH FIXES** his 16-inch scope in the 1960s. No ladder was needed; the scope's frame served as scaffolding.

COURTESY LOWELL OBSERVATORY

**ALMOST 50 YEARS** after his discovery, Tombaugh returned to the telescope that changed his li e.

Stern says he is amazed not only "that a boy off the farm did what the professional astronomers couldn't accomplish in almost 30 years of searching," but also that Tombaugh "never once came to his boss with a false alarm — he came to his boss precisely once." That was in mid-February 1930, after blinking a plate taken January 23 and another taken January 29, both from a region of the northern winter sky near the star Delta (δ) Geminorum.

"And he had it," says Stern. "I think that's pretty amazing. He looked at thousands of plates, each one with thousands of stars, and many asteroids — it's just mind-numbing what he did."

The discovery's public announcement brought fame and accolades from around the world; the story was covered extensively in newspapers worldwide. Clyde Tombaugh would remain a celebrity in astronomical circles for the rest of his life.

## A genuine hero

The news was especially welcome in Burdett, Kansas, where Tombaugh was celebrated as a local hero. The high-school principal, Charles Dilley, arranged a scholarship for Tombaugh so he could enroll at the University of Kansas, where he would eventually earn a master's degree in 1939. And it was also in Kansas that a young woman named Patricia Edson (Patsy, to her friends) first saw a photograph of her future husband.

Patsy was also immersed in celestial matters, largely due to her brother James, an astronomy student who would be a classmate of Clyde's. "I lived in Kansas City, Missouri, and my brother, James, was going into astronomy," recalls Mrs. Tombaugh, now 92. "We were all going up to K.U. to get our college education."

Newspaper headlines of Tombaugh's accomplishment grabbed everyone's attention. "My brother brought the picture of Clyde from the *Kansas City Star* and said 'You're going to meet that fella, because we're going to be classmates,'" she says. "So that's how I met Clyde."

Patsy's own interests leaned toward art and philosophy, but with her brother and a small circle of friends — including Clyde — there were endless conversations about astronomy, space exploration, and life beyond Earth. "But we didn't talk to other people about it," she recalls, or they would have "thought you were out of your mind." They formed a club called, appropriately enough, the Syzygy Club (named for a term referring to the alignment of three astronomical bodies).

Tombaugh's research took up enormous amounts of time, and being a celebrity planet-finder only added to the demands on him. But, says Patsy, none of this changed her husband's personality. "Clyde was a very down-to-earth kind of person," she says. "He didn't get egotistic about any of his accomplishments. He never changed

LOWELL OBSERVATORY

**1931** *Tom augh at the eyepiece of the 13-inch "Pluto" Telescope at Lowell Observatory*

**1932** *Enters the University of Kansas as an astronomy student*

**1934** *Marries Patricia Edson*

**1935** *Clyde and Patricia at Lowell Observatory*

**1936** *Earns Bachelor of Arts degree in astronomy from the University of Kansas*

**1938** *Tombaugh at the link comparator*

**1939** *Earns Masters of Arts degree in astronomy from the University of Kansas*

**1940** *Clyde and atricia's first child, Annette, is born*

**1945** *Lowell Observatory's search for trans-neptunian planets ends*

**READY** for a full day of blinking, Tombaugh stands outside the Slipher Administration Building at Lowell Observatory in July 1932.

COURTESY LOWELL OBSERVATORY

**AS A STUDENT,** Tombaugh spent much of his time at the eyepiece of the University of Kansas telescope. In this 1936 image, he observes through a 6-inch telescope.

his attitude toward people or life or anything. He was just Clyde."

## Pieces of a life

Pluto's discnvery triggered a search that would continue for over a decade. All those years of exaiining phot raphic plates turned up variable stars, star clusters, more than a dozen asteroids, and two comets.

During the late 1940s and into the 1950s, Tombaugh worked on a classified project for the U.S. Army at its rocket-te ng site in White Sands, New Mexico. One of his main tasks was to design optical telescopes capable of trackin balli tic miss les. I the mid-1950s, he conducted a photographic search for small Earth-orbiting natural satellites.

The plates from Tombaugh's transneptunian sea ch would also help astronomers doing another kind of study, decades later. Comparisons between those plates and newer images from th 1960s revealed important information on the proper motion of nearby stars, moving slowly against more distant background stars.

But perhaps most significant were Tombaugh's observations of nearly 30,000 galaxies — about 20 times the number known up to that time. It wasn't just the sheer number of galaxies that was important — it was how they were distributed across the sky. What he found was unexpected: Rather than being distributed evenly, as most astronomers — including the famous Edwin Hubble — had predicted, they clustered into cl arly efined groups. Tombaugh also revealed details of the first-known supercluster — a cluster of galaxy clusters — now known as the Pisces-Perseus Supercluster. He called it the "Great Perseus-An romeda Stratum of Extra-Galactic Nebulae."

Hubble dismissed the work out of hand. To him, it contradicted the cosmological principle he believed guaranteed a smooth distribution of matter in the universe, even, hC assu ed, at the scale of galaxies. It also seemed to contradict Hubble's own galaxy survey, carried out at Mount Wilson Observatory near Los Angeles.

"Hubble had done this survey, showing that 95 percent f he galaxies were not in clusters. Well, it's xactly the pposite," explains Skiff. "He was dead wrong. Ninety-five percent o the g laxiesnb long to clusters."

What Tombaugh found, Skiff says, was a "huge stratum of galaxies th t's sort of o e wall of the spongy structure of the larger cosmos." Moreover, he published his finding — which was a "pretty brave thing to do," says Skiff, especially considering that Tombaugh had not earned a Ph.D. And still he was bold enough "to go up ag nst Hubble."

Tombaugh spent the latter part of his career at New Mexico State University (NMSU) in Las Cruces, where he helped cre te the astronomy department. He taught at NMSU for more than'20 years. Even after his retirement in 1973, Tombaugh kept busy writing and lecturing for over a decade. He also wrote a popular book, *Out of the Darkness*, in which he reKount'd the Pluto story and other astronomical adventures.

Tombaugh was also a regular at the nation's largest star parties and other gatherings of amateur astronomers. While a handful of professional astronomers may have looked down on Tombaugh — perhaps because he never earned a Ph.D. — amateurs always welcomed him with open arms.

David evy recalls a meeting with ama teur astronomers in Pennsylvania when he

**1945**
*Clyde and Patriciais second child, Alden, is born*

**1946**
*The Tombaugh family moves to Las Cruces, New Mexico*

**19,6–19 5**
*Tombaugh works in the ballistics research lcboratory at White Sands Missile Range in Las Cruces*

**c aca 1948**
*Annette and Alden*

**1952**
*Fro left, Clyde, Annette, Patricia, and Alden*

**1953–1956**
*Tombaugh leads a search for other near-Earth natural satellite*

**1955**
*Tombaugh joins the New Mexico State University (NMSU) faculty in Las Cruces*

**1960**
*Awarded honorary doctorate of astronomy degree from Northern Arizona University*

**1968**
*Works to create a Ph.D. progr y in astronomy at NMSU*

**TOMBAUGH'S WIFE AND CHILDREN** visit the 13-inch "Pluto" Telescope at Lowell Observatory in 1954.

**A YOUNG FAN** eagerly looks through the 16-inch scope at Tombaugh's Las Cruces, New Mexico, home.

accompanied Clyde and Patsy on a lecture tour. Afterward, "They had a little party at the home of one ofethe members of the club. Clyde was sitting in a chair, and the whole group was sitting on the floor around him. It was like Santa Claus. T is guy was s loved by the amateur community."

Tombaugh was famous for his puns, and he was especially fond of j k s involving crows. (Where do crows go to drink? The crow-bar, of course.)

And Tombaugh kept gazing skyward. He used several of the three dozen mirrors that he had ground throughout his life. One of his favorite telescopes — a 16-inch reflector — saw a great deal of use before he died of congestive heart failure January v7, 1997

## Unchanging legacy

Today, the planet that Tombaugh worked so hard to uncover is again in the news. After a decade-long voyage, the New Horizons spacecraft will fly past the ninth planet. While at Pluto, the spacecraft will alsos study Pluto's moons: Charon, and the recently discovered S/2005 P1 and S/2005 P2.

Pluto has also been on astronomers' minds because of its status as the solar system's outermost planet. Recently, astronomers have found objects as large or larger than Pluto far from the Sun. Some astronomers argue this sim dytmakes Pluto one of several planets that lie beyond Neptune; others say none of these objects — including Pluto — deserves to be called a planet.

When Pluto was discovered, it appeared to b an oddball at the edge of the solar sys - tem. Now, however, astronomers see it as one of thousands of rocky bodies that make up the Kuiper Belt, a ring of small, icy bodies extending from Neptune's orbit out to perhaps 5 times farther.

While most Kuiper Belt objects are tiny, one exceeds Pluto in size: an object known as 2003 $UB_{313}$, discovered in 2005 by astronomers using the Samuel Oschin Telescope at Palomar Observatory. With a diameter of about 1,680 miles (2,700 kilometers), it is more than 250 miles (400 km) wider than Pluto (believed to be 1,410 miles [2,274 km] across). The International Astronomical Union has discussed the possibility of designating all of these objects — including Pluto — "trans-neptunian planets."

Tombaugh lived long enough to witness some of the debate over Pluto's status. "During Clyde's final years of life, he was extremely upset that his signature discovery was in doubt this much," says Levy. Pluto is, at the very least, the brightest member of the Kuiper Belt — even if it is not the region's largest member, Levy points out. And no matter what history eventually decides about Pluto, he says, Tombaugh's legacy will stand intact. "Clyde's main accomplishment is that he opened the door to the outer part of the solar system."

By scrutinizing every kind of object seen in the heavens — near and far — Tombaugh was far more than the 20th century's greatest planet-hunter. Through hard work and the most careful observations possible, he opened up a new window on our universe.

**ONLINE EXTRA** Read how today's searches are performed at www.astronomy.com/toc.

COURTESY LOWELL OBSERVATORY

**1970** *NMSU establishes an astronomy graduate program*

**1972** *NMSU dedicates the Clyde Tombaugh Observatory*

**1973** *Retires from NMSU as Professor Emeritus*

**1978** *Tombaugh at the Zeiss blink comparator at Lowell Observatory*

**1980** *Writes (with Sir Patrick Moore)* Out of the Darkness, The Planet Pluto, *an autobiographical account of the Pluto discovery*

**1984** *Tombaugh with a telescope he built*

**1990** *Clyde and Patricia at their home in Mesilla Park, New Mexico, with Clyde's 9-inch telescope*

**January 17, 1997** *Tombaugh dies at his home*

# Cool science

Acidic clouds and a surface hot enough to melt lead make Venus unique among planets. Scientists want to know how it got that way. /// BY BRUCE DORMINEY

Venus gleams brightly in the morning sky this month. Its glare, like the landing lights of an approaching jumbo jet, makes it seem deceptively near. In fact, Venus approaches Earth more closely than any other planet. It swings within 26 million miles (42 million kilometers) of Earth — a bit more than 100 times our Moon's distance. But for all its brilliance and proximity, the planet's nearly featureless disk gives up few secrets. At its heart, Venus remains a mystery.

Astronomers once thought of Venus as Earth's twin. But after decades of study from ground-based telescopes and space-probe reconnaissance, scientists have learned Venus is more a hellish parody of Earth than its twin.

## Topsy-turvy Earth

It takes Venus about 225 days to orbit the Sun. The planet spins once on its axis every 243 Earth days, and it does so in the direction opposite Earth and most of the other planets. From Venus' surface, the Sun rises in the west and sets in the east, but perpetual clouds hide its disk from view. The planet's solar day, or the time between successive noontime passages of the Sun, lasts 117 Earth days thanks to the curious interplay of Venus' slow, backward rotation and its rapid orbital speed.

A thick carbon-dioxide atmosphere crushes the planet's surface with more than 90 times the pressure at Earth's surface. Thanks to carbon dioxide's penchant for trapping heat (the so-called greenhouse effect), Venus' surface has a constant temperature of 870° Fahrenheit (465° Celsius). That's nearly twice the temperature of a conventional oven — and hot enough to melt lead, zinc, and even tellurium.

Night is as warm as day; the poles are as warm as the tropics. There are no seasons. The entire atmosphere undergoes a "super rotation" — it circles the planet in as little as 4 days at the equator. Dense, yellow-tinged clouds veil the surface. Their content: sulfuric acid droplets.

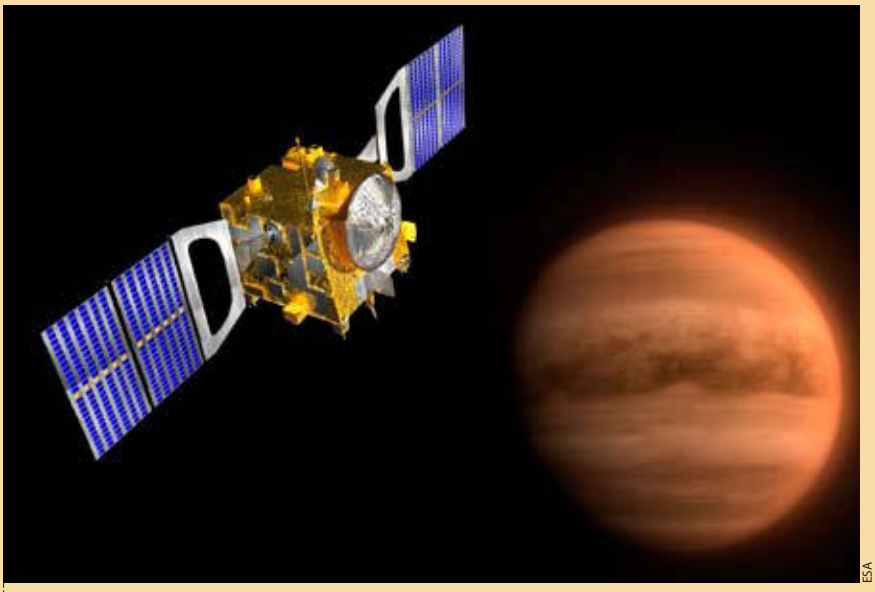
On its surface, Venus is one of the dreariest places imaginable. Almost everywhere, surface rocks are colored gunmetal. Thick clouds reduce sunlight to what we'd experience during a thunderstorm on Earth. And the planet's dense atmosphere scatters blue light so effectively, a golden hue suffuses everything.

Yet, in terms of bulk properties, no two planets in the solar system are a closer match than Earth and Venus. Venus

**Bruce Dorminey** *is the author of* Distant Wanderers: The Search for Planets Beyond the Solar System *(Copernicus Books, 2001).*

# on a hot world

**A FUTURE VENUS ROVER** visits its technological forebear, one of the Soviet nera landers. On December 15, 1970, an sarly model, Venera 7, became the first human-made object to return data from the surface of another planet. Later versions returned images from the surface.
MICHAEL CARROLL FOR *ASTRONOMY*




**VENUS EXPRESS** is scheduled to arrive at the veiled planet in early April.

## CRUISING TO A HELLISH PLANET

Venus Express, the European Space Agency's (ESA) $267 million premier mission to Venus, will make the first global survey of the planet's atmosphere at wavelengths from the ultraviolet to the near-infrared. To keep costs down, most of the probe's instruments are modified flight spares from ESA's Mars Express and Rosetta missions.

According to project scientist Håkan Svedhem, the spacecraft will use its array of seven instruments to study the global atmosphere, peer into the cloud decks, and examine the surface for hot spots. "It would be great to discover an active volcano and to prove that the planet still is active geologically," he says.

After the spacecraft's April arrival, controllers will carefully adjust its orbit. Science observations are expected to begin in early June. The probe will circle Venus once every 24 hours. Using a highly elliptical polar orbit, Venus Express will come within about 155 miles (250 kilometers) of the planet's high northern latitudes. It will use its distant vantage point at the other end of its orbit — some 41,000 miles (66,000 km) below Venus' south pole — to study the planet's global dynamics, including the atmosphere's "super rotation."

ESA plans the mission to last two full planetary revolutions, or about 500 Earth days. But Venus Express carries enough fuel to maintain its science orbit for twice this long.

Svedhem predicts that 6 months after receiving the first data from Venus Express, a plethora of Venus-related papers will emerge from the research community.

"Venus was the forgotten planet," he says, "but it's on the map again." — *B. D.*

receives twice as much solar radi tion as Earth because itis c□ oser □ oythe Sun, ut itsthick cloud r flect 80 percent of that radia tion back into space. This gave rise to early conjecture that Venus might be haspitab□ e ta ife In fact, until th mid-1960s, some Ccientists spec late Venu could be cov ered in microbe-laden swamps or harbor hot oceans filled with acid-loving algae.

Buy le s optim s□ ic scenarios turned out to be closer to reality. Venus has one of the driest, most barren landscapes in the solar system, one that scientists believe has lost an ocean's equivalent of water. It's 100,000 times drier than Earth.

Spa□ e p ob0s have flown past Venus, dropped balloons to study its clouds, mapped it from orbit uAiTg radar, and returned images from the surface. Yet, 44 years after NASA's Mariner 2 made the first successful Venus flyby, scientists still scratch their heads over why Venus is so utadically different from Earth.

Presumably, the two worlds were once more similar. If so, what changed? When in its history did Venus begin sliding down the path to a runaway-greenhouse world? Eleven years had passed between the 1994 demise of NASA's radar-mapping Magellan orbiter and□ last N□ ve ber's launch of the European Space Agency's (ESA) Venus Express, the most recent mission dedicated to e lan□ t. Scientists hope new data will provide further insight into our neighbor's evolution, but mosf bolievedVenus was doomed from the start.

### Water, water — nowhere

"Venus' high surface temperature essentially drov the water into th atm sphlre and created a water greenhouse," says Roger Phillips, a planetary scientist at Washington University and director of the McDonnell Center for Space Sciences in St. Loui□ .□ Water vapor is also an effective greenhouse gas — it's the most significant one n Earth.P A water-rich venusian atmosphere guaranteed a hot surface.

Astronomers think the young Sun increased its energy output by 10 percent every billion years. Even so, some theorists believe significant amounts of liquid water could have survived on Venus for a billion years or more. Eventually, though, all of Venus' liquid water must have boiled off.

Unlike Earth, Venus either never developed a magnetic field or ceased generating one long ago. This left the planet especially vulnerable to the ravages of the solar wind, the stream of electrically charged particles emanating from the Sun. Exposure to the solar wind helped accelerate the pace at which Venus lost both hydrogen and oxygen — the ingredients of water — to space.

The Sun's ultraviolet radiation splits water vapor rising high enough in the atmosphere into hydrogen and oxygen ions. The solar wind flows around Venus like a stream around a stone, picking up stray ions and carrying them off. Worse yet, charged particles take corkscrew paths through the solar wind's magnetic field. Before departing Venus completely, ions may loop deep into the atmosphere, striking and breaking up additional molecules.

"With no magnetic field to protect it, that water was lost," says Phillips. As this was happening, Venus' high surface temperature drove carbon out of the rocks and into the atmosphere, which created the planet's current carbon-dioxide-driven greenhouse conditions. According to Phillips, it will take a geochemist's eye looking at future Venus samples to determine how

NASA/JPL/MATTIAS MALMER

**THIS VIEW** awaits future space travelers to Venus, our nearest planetary neighbor. This mosaic of 78 images returned by Mariner 10 as it passed Venus in 1973 shows somewhat more cloud detail than the human eye would perceive.

NASA/JPL

**PEERING THROUGH THE CLOUDS,** the Magellan spacecraft's radar mapped 98 percent of Venus' surface at resolutions better than 330 feet (100 meters). Venus lacks broad, deep basins like those holding Earth's oceans. Color is simulated in this mosaic.

much water was in Venus' mantle when the planet formed.

The amount of carbon dioxide ($CO_2$) in Venus' atmosphere roughly equals what's in Earth's limestone deposits. Limestone forms from the calcium-carbonate shells marine organisms create, so life played an integral role in sequestering Earth's carbon store. As a side effect of life's success, our atmosphere's oxygen content rose. But, as far as we know, Venus never developed life.

There's another crucial difference between Earth and Venus. Earth's crust is broken into large plates whose horizontal motion drives earthquakes and volcanoes and builds mountains. Scientists call this process plate tectonics. When one plate overruns another, the lower plate's edge is forced deep into Earth's crust, where it melts down. Plate tectonics enables our planet to recycle surface materials like limestone and carbon continually. In contrast, Venus shows no evidence of Earth-style plate tectonics or its attendant chemical recycling.

## Repaved planet

Alex Pavlov, a paleoclimatologist at the University of Colorado in Boulder, says the biggest mystery is not why Venus had a runaway greenhouse, but rather on what timescale? Did it happen immediately, or later in its evolution?

Data gathered by the Magellan spacecraft, which mapped nearly the entire surface of Venus, show most of the surface is geologically young. Studies from orbit reveal two main types of landforms on Venus: smooth volcanic plains, which make up about 80 percent of the surface; and intensely deformed, elevated plateaus called tesserae (8 percent).

Like every other body in the solar system, Venus also has impact craters. But of the 1,000 craters Magellan cataloged, most appear pristine. Scientists believe they have a good idea of the asteroid and comet flux in the inner solar system, yet Venus simply doesn't bear the level of impact scarring so evident on the Moon and Mars.

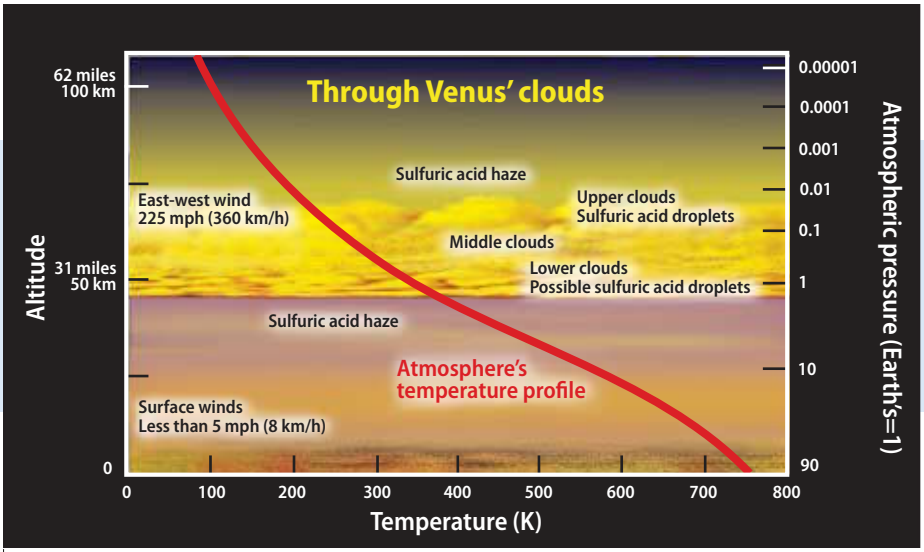
Dating Venus' surface on the basis of crater counts leads to the conclusion that what we see is no more than a billion years old. "Venus' surface is amazingly young," says James Head, a planetary geologist at Brown University. "It's more like the average age of Earth's surface, rather than the Moon, Mars, or Mercury."

Much of the planet has been resurfaced in the past billion years. The oldest features are the highland tesserae, which formed by extensive folding and faulting of the surface. Various stages of volcanism followed, apparently in a style very different from Earth's. On Venus, there's no sign of plate tectonics. Venus' last major volcanic episode flooded 40 percent of the surface with basalt lavas, erasing all landforms except the highest tesserae. Volcanism that followed this massive repaving was less dramatic, steadier, and more localized. The craters Magellan mapped are scars from impacts received only after most of this activity subsided.

Why is Venus' tectonic style so different from Earth's? Again, it may come down to water. Earth's process of plate tectonics recycles surface materials, first drawing them into the planet, then releasing them again through volcanism. Water plays a role in keeping the mantle and crust lubricated and mobile. On Venus, this ingredient disappeared. Perhaps the planet's crust became so thick and hot that it eventually ruptured in a great volcanic episode.

## Left behind

Spacecraft have shown that Venus' atmosphere has a much higher ratio of deuterium (a heavier variant of hydrogen) to normal hydrogen than Earth's oceans. The deuterium was more resistant to escape, and as normal hydrogen left, the fraction




ASTRONOMY: ROEN KELLY

**SLICING THROUGH VENUS' thick atmosphere shows how different it is from Earth's. Scientists have confirmed the presence of sulfuric acid only in the uppermost clouds. Some evidence suggests the middle clouds are made of non-spherical particles, possibly crystals. If so, more exotic chemistry must be at work. Temperatures in the lower atmosphere increase steadily toward the surface, reaching 870° F (465° C, or 740 kelvins).**

NASA/JPL

**VENUS' LOWER CLOUDS shine at night in the infrared. The Galileo spacecraft mapped Venus' nighttime heat when it flew 60,000 miles (100,000 km) from the planet February 10, 1990.**

of deuterium rose. Venus now has a ratio of deuterium to hydrogen about 150 times greater than terrestrial oceans. This is a clue that Venus once had much more water than it does today.

## Life in the clouds?

But might life have arisen there as it did on Earth? And if microbes did evolve, could they have survived long enough to migrate into Venus' cloud decks? That's an idea championed by some astrobiologists.

Dirk Schulze-Makuch at Washington State University is one of them. He notes that pressures and temperatures in Venus' middle atmosphere are much more conducive to life than those at the surface. He believes microbes may have evolved to produce a kind of sunscreen from sulfur compounds, and he gives Venus a 50/50 chance of still harboring microbial life. Schulze-Makuch advocates using an atmospheric probe to look for life in Venus' clouds. He reasons that life would be easier to find there than below the surface of Mars.

Charles Cockell, a planetary biologist at the United Kingdom's Open University, scoffs at the idea. Venus may well have had an ocean, Cockell says, but there is no evidence microbes have been living in its clouds for 3.5 billion years. He adds: "No known organism on Earth uses sulfur as an ultraviolet screen."

## More questions

Venus leaves us with many puzzles. Scientists still debate why Venus spins opposite Earth and most of the other planets.

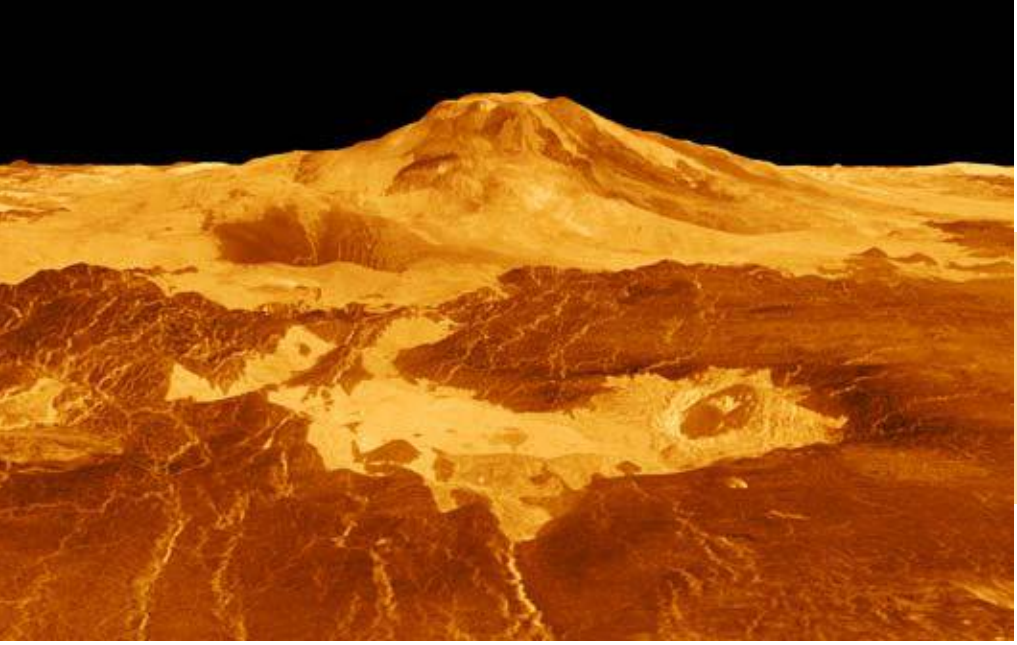
Jacques Laskar, an expert in celestial mechanics at the Paris Observatory, believes that as Venus wobbled around the Sun early in its history, friction between its core and mantle left the planet vulnerable to changes in its spin axis and a further slowing of its rotation.

Laskar thinks Venus probably was born with a relatively fast spin, but its close proximity to the Sun produced intense tides that gradually slowed the planet's rotation. He thinks the motions of its dense atmosphere either nudged Venus into a slow, backward spin or, more likely, simply flipped the planet 180° on its head.

Laskar's previous studies have shown our Moon helped stabilize Earth's spin axis

**THE SURFACE of Venus is made up of platy volcanic rocks. The Soviet Venera 13 lander returned this panorama March 1, 1982. The horizon is visible in the upper left and right corners, and the camera's lens cover appears on the surface near the image's center.**

BROWN UNIVERSITY/VERNADSKY INSTITUTE/OLIVIER DE GOURSAC, FROM *VISIONS OF MARS*



NASA/JPL

**USING MAGELLAN DATA, scientists created this three-dimensional view of Maat Mons, a venusian volcano that rises 2 miles (3 km) above the surrounding terrain and 5 miles (8 km) above the planet's mean radius. Lava flows extend for hundreds of miles across the fractured plains shown in the foreground. This view exaggerates terrain elevations by 10 times. Scientists simulated the colors based on spacecraft images taken at the surface.**

over millions of years. Without the Moon, our planet's axis would have undergone unpredictable and dramatic changes driven by the gravitational influences of the other planets. Laskar has shown these effects would have been capable of tipping Earth's axis as much as 85° in a few tens of millions of years. But unlike Earth, Venus has no large satellite to serve the same function.

To answer the full range of outstanding questions about our planetary neighbor, scientists say we must return to Venus with multiple spacecraft over the next few decades. David Crisp, an atmospheric physicist at the Jet Propulsion Laboratory in Pasadena, California, has studied future Venus missions extensively. He contends NASA's current Mars-focused strategy gives us an incomplete picture of the inner solar system, one that will leave us unprepared to interpret other planetary systems.

"When we start looking at extrasolar terrestrial planets and see a lot more Venus-like worlds ... I don't know if we'll even understand how to categorize those planets — especially considering that we don't understand Venus, and it's right next door," Crisp says.

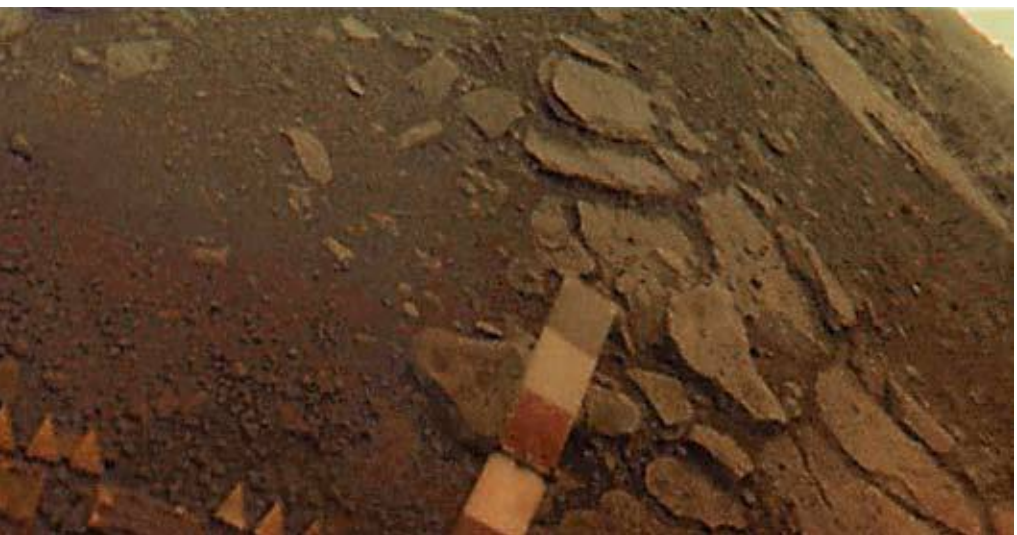
Beyond ESA's Venus Express, now en route, is Venus Climate Orbiter, a Japanese probe slated to begin studying our neighbor in 2009. Future NASA missions to Venus might include multiple surface spacecraft to serve as a global seismic-monitoring network. New orbiter missions might be dedicated to examining the atmosphere's composition. Long-duration balloons could sample cloud makeup and study the atmosphere's vertical structure. Researchers would like to see at least three landers, each studying different surface regions, and, ultimately, a few missions capable of sending venusian geological samples back to Earth for detailed analysis.

Yet Crisp believes we will be lucky to see any sort of NASA mission to Venus before 2030. He puts sample-return missions even farther down the track, if only because the technology to withstand the surface temperatures and pressures for extended periods of time simply do not yet exist.

"Venus is even more interesting than the Moon," says Paul Lowman, a geophysicist at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "I am disappointed NASA isn't doing more with Venus."

What would he do with a budget for Venus missions? "I'd put down landers and rovers," Lowman says. "The atmosphere is hellish, but the engineers could beat it."

In the meantime, Venus Express will take up the challenge of providing scientists with a coherent picture. Venus, the brightest and closest to Earth of all the planets, has fascinated stargazers and scientists alike for centuries. No one expects it easily will surrender its remaining secrets.



### /// QUICK VENUSIAN FACTS

## NEIGHBOR PLANET

**Diameter:** 7,521 miles
12,104 kilometers
0.95 Earth

**Mass:** 10.7 x $10^{24}$ pounds
4.9 x $10^{24}$ kilograms
0.82 Earth

**Surface temperature:** 870° F (465° C)

**Surface atmospheric pressure:**
92 times Earth's

**Atmospheric composition:**
96.5-percent carbon dioxide
3.5-percent nitrogen

**Rotation period:** 243 days, opposite Earth's rotational direction

**Solar day:**
117 times longer than Earth's

**Axial tilt:** 177.4°

**Sidereal orbital period:** 224.7 days

**Synodic orbital period:** 583.9 days

**Mean distance from Sun:**
67.2 million miles
108.2 million kilometers
0.72 AU

**Orbit inclined to Earth's:** 3.4°

**ONLINE EXTRA** Learn more about upcoming Venus missions at www.astronomy.com/toc.

BY MARTIN RATCLIFFE AND ALISTER LING

# FEBRUARY 06

Brilliant Venus brings small-scope owners great views of its changing phase when the planet vaults into the morning sky this month. After sunset, Mercury puts on its best evening show of the year.

## Lord of the rings returns

Most observers agree that Saturn is a wonderful sight through a telescope. The ringed planet perches nicely in the evening sky for the next several months. But how do you pick it out from the multitude of bright winter stars commanding the southeastern sky? A twinkling, colorful point of light will first draw your attention. This is brilliant Sirius, the brightest star in the sky. Above it, the bold outline of Orion with its conspicuous "belt" of stars penetrates the crisp air. The red supergiant star Betelgeuse tops this bright group.

One luminary in this region looks different, however. If you're new to observing, you might not even notice the object that's not twinkling, lying to the left of the other bright stars. The steady light signifies a planet — in this case, Saturn. Binoculars provide an additional treat: Saturn sits on the edge of the striking Beehive star cluster (M44). A telescope reveals the planet's rings, which captivate even experienced observers. The best views come in midevening, once Saturn has risen well above the turbulent heat escaping from rooftops.

At the end of January, the Sun, Earth, and Saturn lined up in a configuration astronomers call opposition. During the next several weeks, look closely at where the planet's disk blocks the rings from view. You will see a thin black line develop — the shadow of the gas giant's atmosphere — and slowly grow as Earth's vantage point shifts.

**VENUS GLEAMS this month, when it climbs higher in the morning sky and shines at its brightest for the year.** ANDREW COTTAM

Mars glows with a fiery orange hue high in the south as darkness falls. Compare its color and brightness with nearby Aldebaran. Throughout the month, watch the planet slide eastward against the stars and south of the Pleiades star cluster (M45). This is a chance echo of Saturn's dance around the Beehive. As enticing as Mars looks to the naked eye, through a telescope, its tiny disk will disappoint all but experienced observers and imagers. Mars' next good visual appearance comes in late 2007.

Speedy Mercury climbs into the twilight for its best evening appearance of 2006. After February 10, point your binoculars just above the point on the horizon where the Sun set 30 to 40 minutes earlier. No bright stars lurk in this area to confuse you. During the next 2 weeks, the innermost planet climbs into a darker sky, making it even easier to see.

Spying an ultra-thin crescent Moon is a popular challenge among skywatchers. Newcomers have a chance to log a personal best February 28, when the Moon will be only 23 hours old as seen from the East Coast. Look below Mercury for a thin, Cheshire Cat smile. The next night, the lunar crescent appears more beautiful because it is filled with earthshine and set against a darker sky.

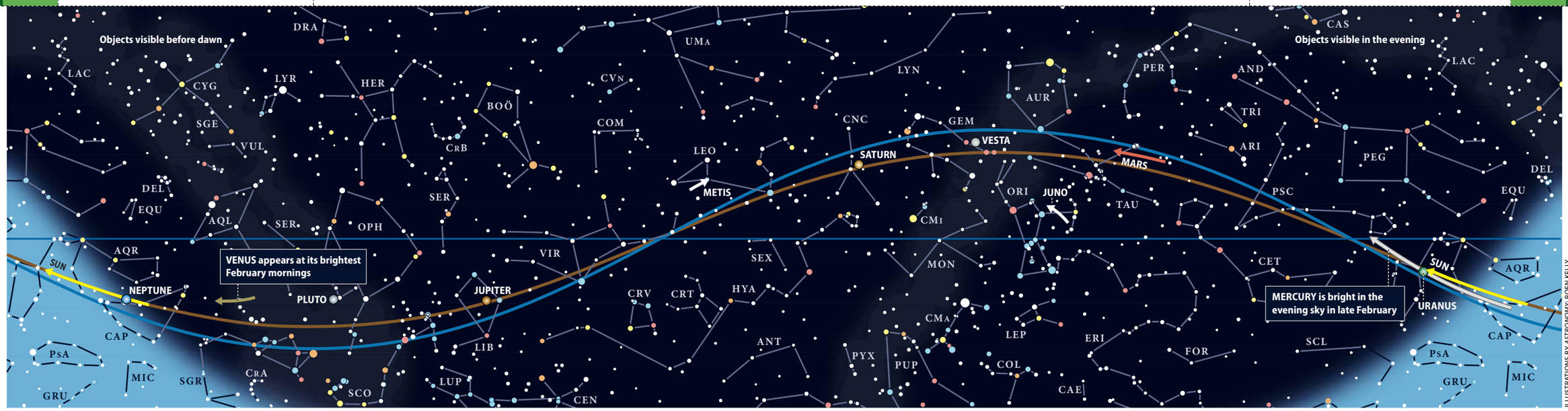
The two brightest planets rule February mornings. Jupiter rises around midnight, but it arcs low across the southern sky for northern observers. It will stay low for the next 5 years as it travels through Libra, Scorpius, Ophiuchus, Sagittarius, and Capricornus. To get the best view through a scope, wait until near dawn, when Jupiter has climbed highest. This avoids the worst atmospheric turbulence low in the sky.

Venus passed Earth on the inside of the orbital racetrack in mid-January. So when we now look toward the planet, we see mostly its shadowed side. Through a telescope, Venus' huge, thin crescent is a sight to behold. Watch this month as the disk rapidly shrinks in size and waxes in phase.

Coursing through the pattern of bright stars called the winter hexagon, the Milky Way brightens noticeably in Gemini. A view through binoculars from under a dark sky reveals countless stars. The bright star cluster M35 stands out as a glowing patch of light.

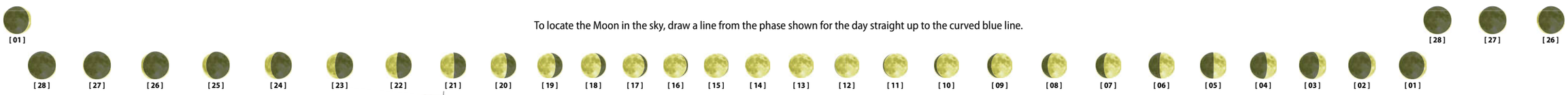
# Planets this month

This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

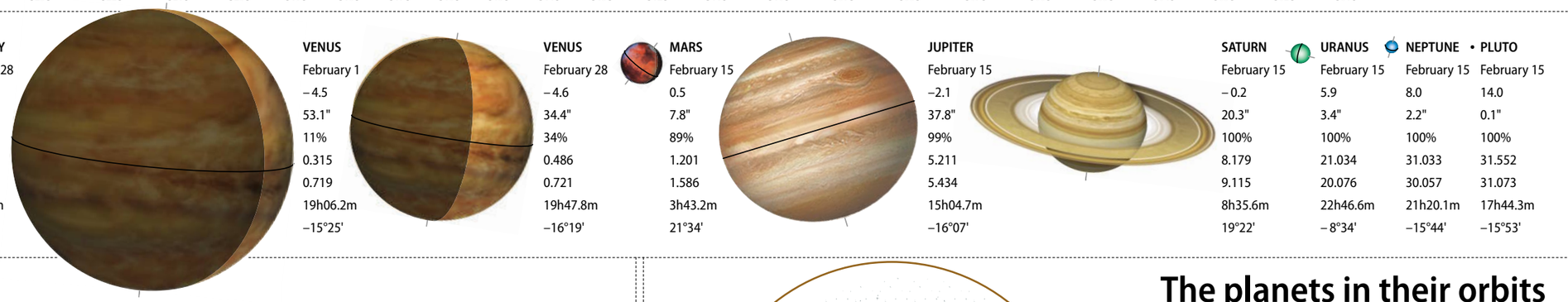



ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.

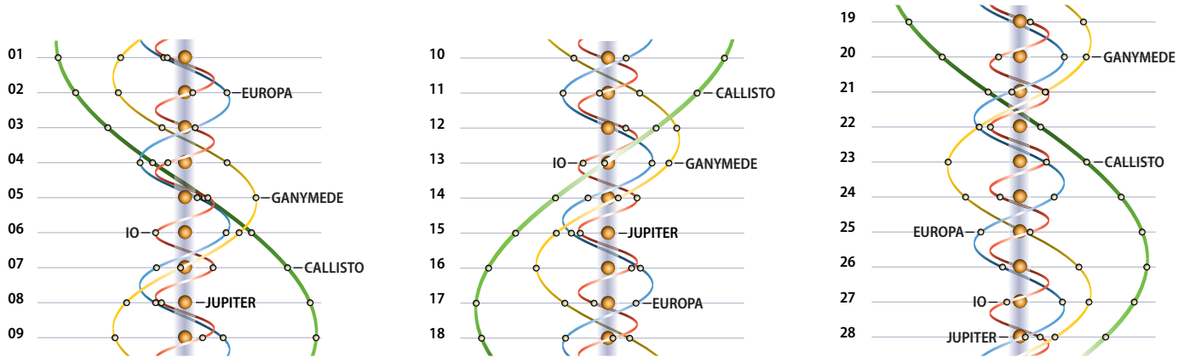



| PLANETS | MERCURY | MERCURY | VENUS | VENUS | MARS | JUPITER | SATURN | URANUS | NEPTUNE • PLUTO |
|---|---|---|---|---|---|---|---|---|---|
| Date | February 15 | February 28 | February 1 | February 28 | February 15 | February 15 | February 15 | February 15 | February 15 |
| Magnitude | –1.2 | 0.1 | –4.5 | –4.6 | 0.5 | –2.1 | –0.2 | 5.9 | 8.0 |
| Angular size | 5.7" | 8.1" | 53.1" | 34.4" | 7.8" | 37.8" | 20.3" | 3.4" | 2.2" |
| Illumination | 83% | 31% | 11% | 34% | 89% | 99% | 100% | 100% | 100% |
| Distance (AU) from Earth | 1.173 | 0.829 | 0.315 | 0.486 | 1.201 | 5.211 | 8.179 | 21.034 | 31.033 |
| Distance (AU) from Sun | 0.326 | 0.315 | 0.719 | 0.721 | 1.586 | 5.434 | 9.115 | 20.076 | 30.057 |
| Right ascension (2000.0) | 22h48.6m | 23h42.4m | 19h06.2m | 19h47.8m | 3h43.2m | 15h04.7m | 8h35.6m | 22h46.6m | 21h20.1m |
| Declination (2000.0) | –8°16' | 0°37' | –15°25' | –16°19' | 21°34' | –16°07' | 19°22' | –8°34' | –15°44' |



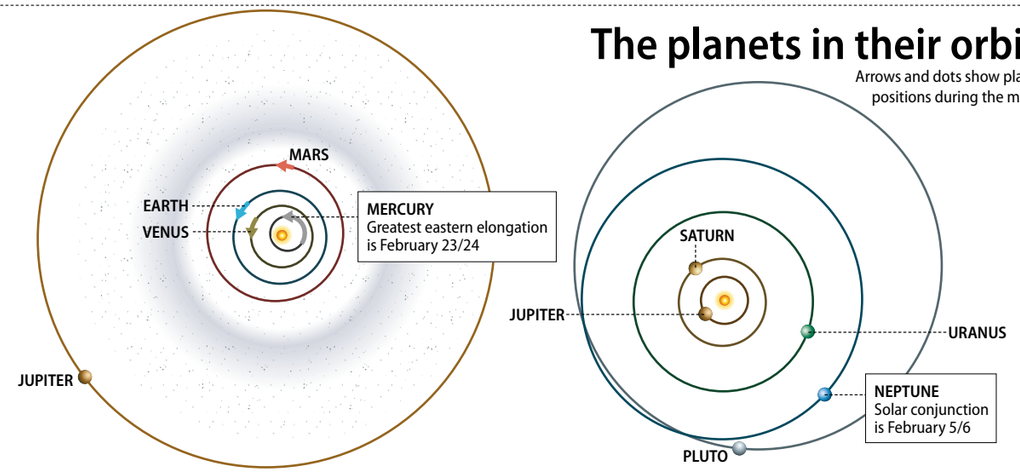

## Jupiter's moons

Dots display positions of Galilean satellites at 5 A.M. EST on date shown. South is at top to match the view through a telescope.



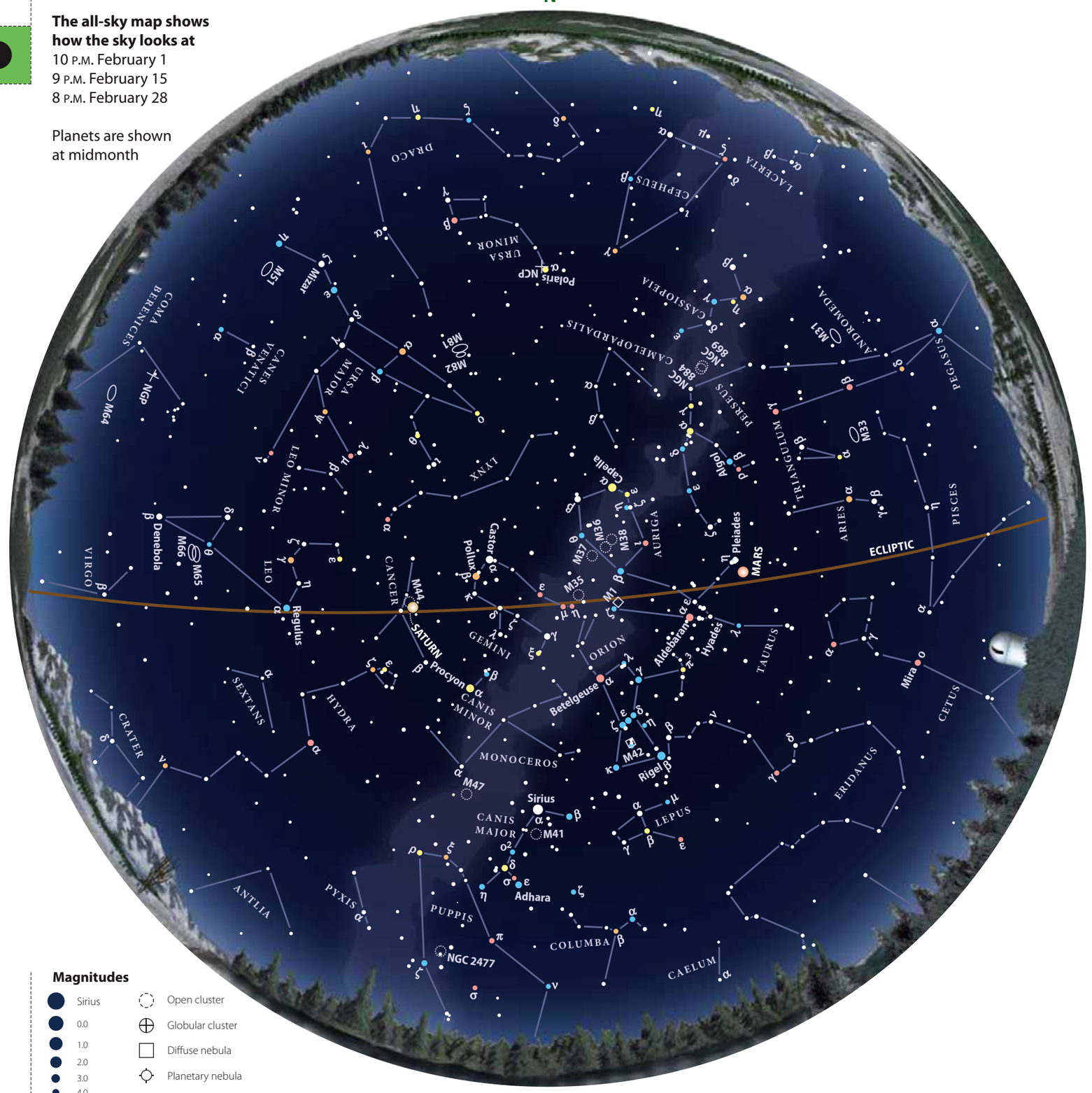

## The planets in their orbits

Arrows and dots show planets' positions during the month.



**The all-sky map shows how the sky looks at**
10 P.M. February 1
9 P.M. February 15
8 P.M. February 28

Planets are shown at midmonth




**Magnitudes**

| | |
|---|---|
| Sirius | Open cluster |
| 0.0 | Globular cluster |
| 1.0 | Diffuse nebula |
| 2.0 | Planetary nebula |
| 3.0 | Galaxy |
| 4.0 | |
| 5.0 | |

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

# february 06

| SUN. | MON. | TUES. | WED. | THURS. | FRI. | SAT. |
|---|---|---|---|---|---|---|
| | | | [01] | [02] | [03] | [04] |
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| [26] | [27] | [28] | | | | |

ILLUSTRATIONS BY *ASTRONOMY*: ROEN KELLY

**03** Venus is stationary, 2 A.M. EST

**05** First Quarter Moon is at 1:29 A.M. EST

The Moon passes 2° north of Mars, 5 P.M. EST

**06** Neptune is in conjunction with the Sun, 1 A.M. EST

**11** The Moon passes 4° north of Saturn, 10 A.M. EST

**12** Full Moon is at 11:44 P.M. EST

**13** The Moon is at apogee (252,500 miles from Earth), 7:47 P.M. EST

**17** Venus is at greatest brilliancy (magnitude –4.6), 3 P.M. EST

The Moon passes 0.4° north of Spica, midnight EST

**20** The Moon passes 5° south of Jupiter, 3 A.M. EST

**21** Last Quarter Moon is at 2:17 A.M. EST

The Moon passes 0.2° south of Antares, 4 P.M. EST

**23** Mercury is at greatest eastern elongation (18°), midnight EST

**24** The Moon passes 10° south of Venus, 4 P.M. EST

**26** The Moon passes 4° south of Neptune, 8 A.M. EST

**27** The Moon is at perigee (221,757 miles from Earth), 3:25 P.M. EST

New Moon is at 7:31 P.M. EST

**28** The Moon passes 4° south of Mercury, 9 P.M. EST

**ONLINE EXTRA** For definitions of terms, visit www.astronomy.com/glossary.

# THE DEEP SKY

The winter sky hosts many great star clusters. Although these clusters look more impressive from under a dark sky, they still pack a punch through urban skyglow.

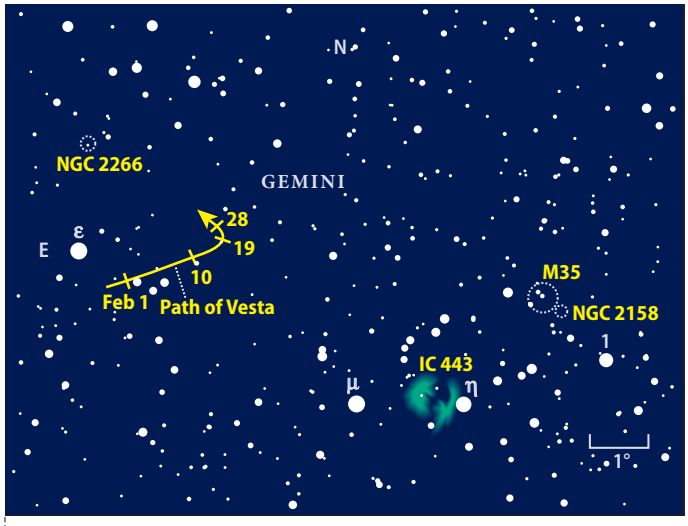
## Splendid sparkles

M35 in Gemini ranks among the sky's finest open star clusters. In fact, observers knew of it well before it became part of Charles Messier's famous catalog of deep-sky objects in the 1760s. Although not as prominent as the Beehive Cluster (M44), which now lurks in Saturn's glare, M35 has a hazy glow visible to the unaided eye on a moonless night from a decent rural site.

You can see M35 through binoculars from the suburbs. The best views, however, come under a dark sky. Wait until after February 15, when the Moon no longer interferes, to see it against the rich tapestry of the winter Milky Way. Your scope will need to cool down anyway, so take a nice long look with your binoculars before jumping to the eyepiece.

Any telescope will deliver a stunning view. You'll see dozens of sparkling stars with a wide range of brightnesses. M35's a lovely sight in a 4-inch scope even from the city — two orange-hued field stars really give it character. From the country, you should notice a small, faint glow southwest of M35. This is another rich star cluster: NGC 2158. It lies 16,000 light-years from Earth, compared with M35's 3,000 light-years, so it doesn't look as impressive. A 10-inch scope easily resolves the tight clump into a mass of individual stars.

Keeping this duo in mind, jump to NGC 2266, located 2° north of Epsilon (ε) Geminorum. It appears as a hazy spot through binoculars or an 8x50 finder. Located 11,000 light-years away, NGC 2266 gives an appearance halfway between the other two clusters. Notch up the power to bring NGC 2266's fainter stars into view and see the cluster's triangular shape.




ASTRONOMY: ROEN KELLY

**STAR CLUSTERS ABOUND** along the winter Milky Way, but few constellations have as many nice ones as Gemini.

N. A. SHARP/NOAO/AURA/NSF

**BIG AND BRIGHT, M35** (left) sits at the foot of Gemini the Twins, where it shares space with the smaller and richer open cluster NGC 2158 (lower right).

## Blast from the past

A long time ago in this part of the galaxy, the core of a massive star collapsed and blasted its outer layers of gas deep into space. Today, we can see this supernova's remnants as a shell of expanding gas. IC 443 appears as a diffuse arc glowing with the energy released as this gas rams into the surrounding interstellar medium.

IC 443 is easy to locate but tough to see. Head to Eta (η) Gem — the star most people use to hop to M35 — and shift 0.5° east-northeast. At a magnification of 50–80x, that's about one-half of the field of view.

IC 443's low surface brightness renders it almost invisible straight through the eyepiece. Thanks to technological marvels called nebula filters, however, you can spy IC 443 in an 8-inch scope. Your best choice is to use a high-contrast (narrowband) filter or OIII filter. To get the most out of any nebula filter, cloak your head at the eyepiece with a dark cloth. The filter's shiny surface reflects stray light, even at a dark site, and reduces the contrast you're fighting so hard to enhance. If you don't have a filter, borrow one from a fellow observer.

While you're in this area, seek out asteroid 4 Vesta. This 7th-magnitude space rock is easy to see through binoculars from a dark site. You can find it west of Epsilon Gem.

# THE PLANETS

Spectacular views of Saturn await observers with telescopes all night long. It highlights evenings that also feature Mars adding luster to Taurus, and Mercury gleaming bright in the twilight.

The best evening views of **Mercury** this year come between February 8 and March 6. During this 4-week period, the planet sets long enough after the Sun to be seen as a bright "star" low in the western sky. On February 8, Mercury sinks below the horizon 45 minutes after the Sun. Look for it in the bright twilight about 20 minutes after sunset, when its altitude is just 4°. Its elongation from the Sun is then 10°, a value that grows to 18° by February 23/24.

After the 8th, Mercury climbs 1° higher each day. Its visibility benefits from the steep angle the ecliptic makes to the western horizon. This orientation occurs in the evening sky each February and March, and it favors the visibility of any evening planet by causing it to set longer after the Sun than at times when the ecliptic lies more horizontal to the horizon.

As Mercury climbs, it passes within 1° of distant **Uranus** February 13 and 14. Although this line-of-sight effect is interesting, Uranus glows dimly at magnitude 5.9 and likely will be lost in the twilight or atmospheric haze.

Mercury stands 18° east of the Sun February 23/24 at its greatest elongation for this apparition. For North American observers, the evening of February 23 should provide the best view. Mercury then shines at magnitude –0.5, and a telescope reveals its 7.2"-diameter, 50-percent-lit disk. You can capture nice images of the planet with a simple camera-on-tripod setup. The most interesting photos include striking foreground objects placed in silhouette. By the 28th, the planet fades to magnitude 0.1, while its disk grows to 8.1" and its phase slims to a 31-percent-lit crescent. For more tips on observing the innermost planet, see "Catch Mercury at its best" on page 74.

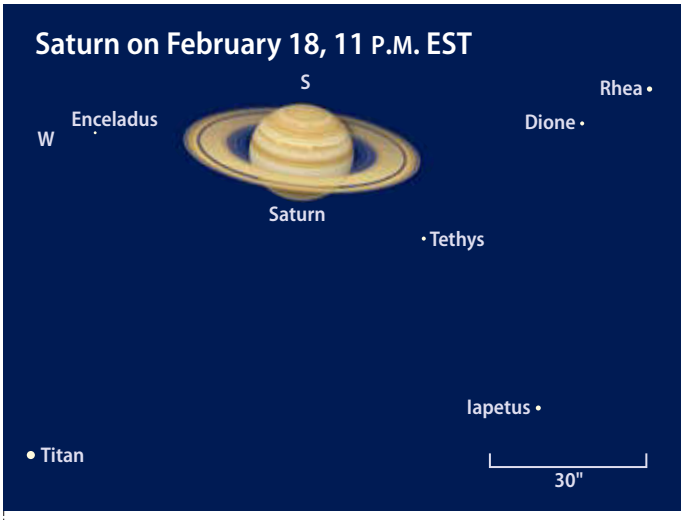
**Mars** spends the first 2 weeks of February approaching the glittering Pleiades star cluster (M45). A First Quarter Moon joins the pair February 5. Mars then lies 6° west of M45, and the Moon lies midway between them. Mars passes 2° south of the Pleiades February 16, when it shines at magnitude 0.5. Its tiny, 8"-diameter disk reveals surface details only in 10-inch or larger scopes.

Notice the similarity in brightness and hue between Mars and Taurus' brightest star, Aldebaran. By the end of the month, the two appear equally bright, shining at magnitude 0.8. Aldebaran is a red giant star with a diameter roughly 50 times that of the Sun. Its red hue comes from its cool surface temperature of 6,600° Fahrenheit (3,900° Celsius). The color of Mars comes from sunlight reflecting off its non-luminous, rust-colored surface. Mars currently lies 10 light-minutes from Earth, while Aldebaran is located 65 light-years away.

You won't find a better telescopic target this month than **Saturn**. It stands fairly high in the east among the background stars of Cancer the Crab once the sky gets dark. Opposition occurred in late January, so Saturn continues to shine brightly at magnitude –0.2. Binoculars will show the planet nestled against the southern edge of the star cluster M44, also known as the Beehive. Chance alignments like this add sparkle to the already beautiful telescopic visage of the ringed planet.

Saturn's disk, which measures 20" across this month, tends to be bland. Yet careful scrutiny with a 6-inch or larger scope reveals subtle atmospheric details. The most obvious are a couple of dusky bands and the darker polar regions.

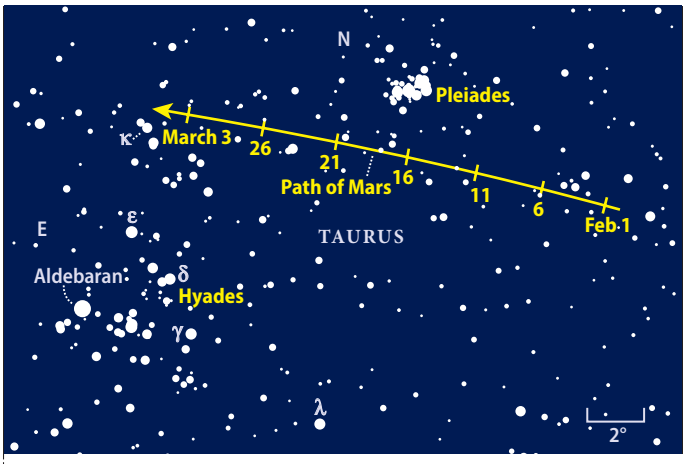
Saturn's rings currently span 46" and have never been described as bland or subtle. The rings tilt 19° to our line of sight, which affords excellent views. You should have no trouble seeing the dark Cassini Division, which separates the outer A ring from the brighter




ASTRONOMY: ROEN KELLY

**SATURN'S BRIGHT MOONS** put on a nice show all month, but they will be easiest to see together the night of February 18/19.

**INTRIGUING ENCELADUS** has a thin atmosphere and possible ongoing geologic activity, both found by the Cassini spacecraft during three flybys in 2005. NASA/JPL/SSI




ASTRONOMY: ROEN KELLY

**MARS GLIDES PAST** the Pleiades (M45) this month, where the blue-white stars contrast nicely with the ruddy planet. The Moon joins the pair February 5.

B ring. And on exceptional nights, the innermost, dusky C ring comes into view.

Any telescope will show Saturn's brightest moon, Titan, throughout its 16-day orbit of the planet. Glowing at 8th magnitude, Titan is typically the brightest starlike object in the same field of view as Saturn, although field stars occasionally confuse the situation. Titan passes due north of Saturn February 2 and 18 and due south February 10 and 26.

The Cassini spacecraft has been taking spectacular images of Saturn's smaller moons. See how many of these moons you can spot through your telescope. The easiest to see are 10th-magnitude Tethys, Dione, and Rhea, all heavily cratered worlds that orbit Saturn in periods between 2 and 5 days. Enceladus proves more of a challenge because it's fainter and closer to Saturn. Cassini has shown this moon to be a water-rich world that is almost certainly geologically active.

Iapetus reached greatest eastern elongation from Saturn at the end of January, when it glowed dimly at magnitude 11.9. The moon brightens throughout February, however. It passes due north of the planet February 19/20 and appears brighter than magnitude 11.0 the rest of the month. You can find this moon in Titan's vicinity February 14, 15, and 16.

**Jupiter** appears over the east-southeastern horizon by 2 A.M. February 1 and is 20° high by this time at month's end. You'll find it 6° above the Last Quarter Moon February 20.

Jupiter spends most of 2006 in the constellation Libra the Scales. Shining at magnitude –2.1 in mid-February, it dominates this region of sky.

You'll get excellent views of Jupiter in the early morning hours. Typically, any daytime turbulence in our atmosphere has settled down by then, dust has subsided, and the spectacular winter sky beckons. The giant planet shows delicate and complex cloud patterns in its atmosphere through any telescope. Jupiter's appearance changes every hour as the planet's speedy rotation carries these features before us.

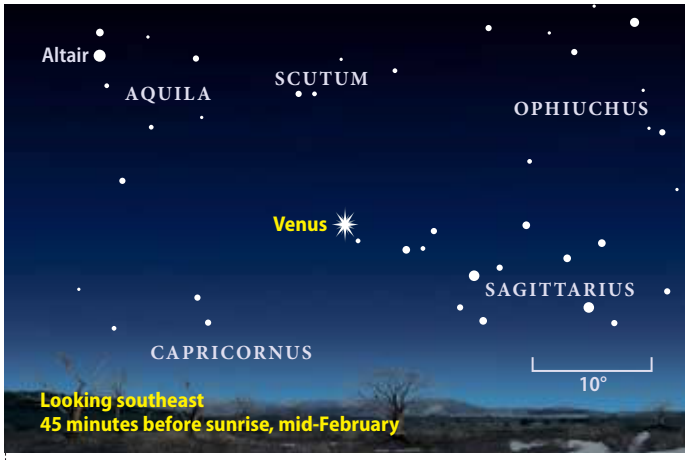
Jupiter spans 38" in February and grows to 45" by the time it reaches opposition in May. Take advantage of the dark, early morning sky to practice observing this planet and training your eye to see detail. You can also try webcam imaging. The salmon-pink Great Red Spot, a rather subtle telescopic feature by eye, shows up easily in digital images.

Jupiter passes 3' north of Nu (ν) Librae, which glows at magnitude 5.2, February 28. Despite a similar brightness, you won't confuse it with Jupiter's four major moons. Io, Europa, Ganymede, and Callisto always lie along a line passing through Jupiter's equator, so any bright object away from this line must be a field star and not a jovian satellite. Each night, the moons' relative positions change. Io orbits Jupiter in 1.8 days, while Europa takes twice as long. Ganymede's orbital period, 7.2 days, doubles Europa's, and Callisto takes 16.8 days. We see their orbits edge-on at all times, so they appear to wander east and west of the planet.

Brilliant **Venus** rises 2 hours before the Sun February 1. So by 6:30 A.M. local time, it gleams low in the southeast. It shines at its brightest this month, reaching magnitude –4.6.

Venus lies in the constellation Sagittarius the Archer. By late February, the planet appears against a dark sky and the spectacular Milky Way — if you're lucky enough to have clear weather and can observe away from the city. On February 24, watch shortly after 5 A.M. local time as the waning crescent Moon rises with Venus. A healthy 13° then separate the pair.

Through a telescope, Venus changes quickly this month. On February 1, the disk appears 53" across and shows a thin, 11-percent-lit crescent. The disk shrinks all month as the distance between Earth and Venus steadily increases. Likewise, the percentage of illumination increases. On February 28, Venus shows a 34"-diameter disk that appears 34-percent lit.




ASTRONOMY: ROEN KELLY

**WATCH VENUS CLIMB** into prominence during February. No other point of light in the sky shines as brightly, so you shouldn't have any problem identifying it.

# METEORS AND MOONS

A smattering of bright, sporadic meteors can appear anytime on these cold February nights. Small backyard scopes will deliver stunning views of a rugged lunar gorge.

## A sparse month

Traditionally, February is a quiet month for meteors. Only one shower — the Alpha Centaurids — exists, and it's a minor one located deep in the southern sky.

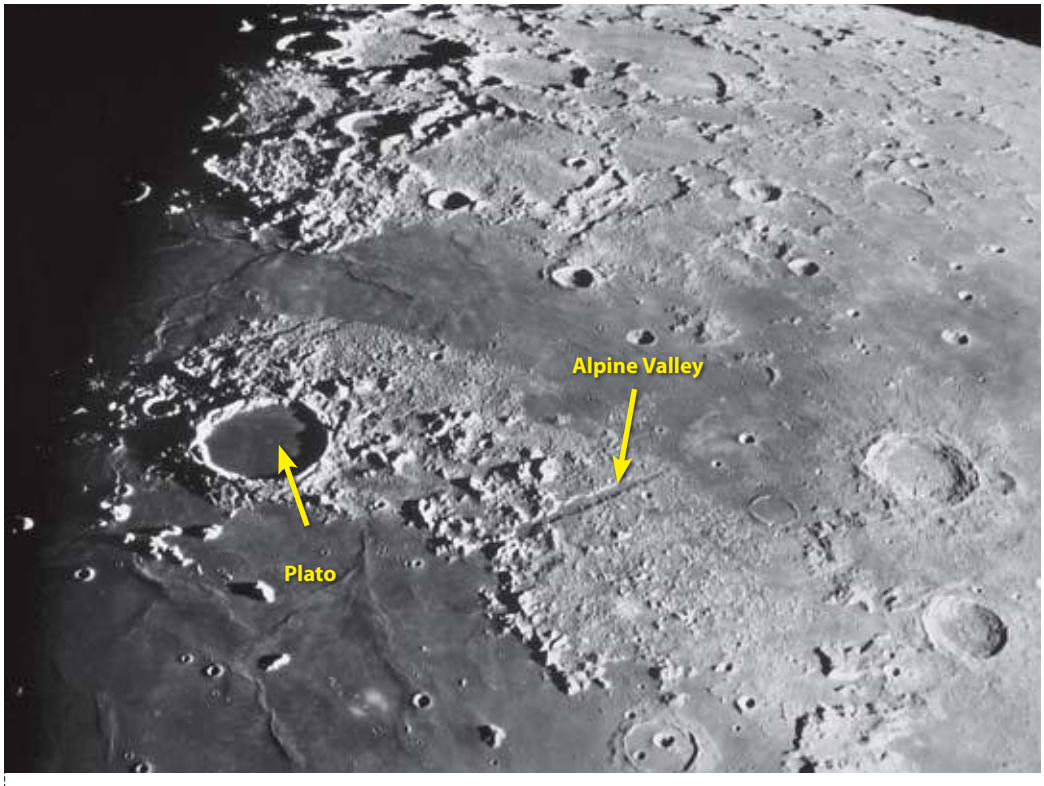
The background rate of sporadic meteors can reach as high as 7 per hour under the darkest skies. These random pieces of flotsam don't occur with enough frequency, however, to deduce any significant meteor stream.

Occasionally, Earth runs into a large lump, and a stunning fireball erupts. Patience and good luck are the bywords for viewing meteors in February. As you watch the fine display of planets during the night, keep an eye out for that big piece of space dust that will create a brief moment of exhilaration.

## The Alpine Valley

Small telescopes show the Moon's Alpine Valley in all its glory. Also known by its Latin name, Vallis Alpes, this striking gorge slices through the lunar Alps not far east of a prominent, 63-mile-wide crater, Plato. The valley stretches 110 miles long and links the vast Mare Imbrium with the lenticular Mare Frigoris. Huge flanking mountains appear to constrict the valley at its narrow southwestern end.

**Martin Ratcliffe** *is the former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*




FROM *CONSOLIDATED LUNAR ATLAS* (LPI/UA)

**THE ALPINE VALLEY — a spectacular, 110-mile-long gorge — cuts a striking figure when the Sun rises over the region around First Quarter phase and when the Sun sets around Last Quarter phase.**

Farther northeast, the valley floor opens into a wide expanse that spans nearly 7 miles. The valley floor appears dark, similar to the lava-filled maria. Running down its middle is a thin, snaking channel, or rille. It's visible under good conditions in a 5-inch refractor and in a well-collimated 8-inch Schmidt-Cassegrain under less-ideal conditions. The Sun rises over this feature around First Quarter phase (February 4/5 this year), and changing lighting conditions reveal the valley's full nature through Last Quarter (February 21).

ROBERTO BOCCADORO

**A FIREBALL CAN ERUPT at any time — even during February, which has no decent meteor shower. Fireballs blaze brighter than magnitude –4, making them at least as bright as Venus.**

# COMETS AND ASTEROIDS

The vast number of asteroids in our solar system and the limited area of sky they ply ensure that coincidental crossings happen now and then.

## McNaught at its best

We've been following Comet C/2005 E2 (McNaught) for a few months now. Actually, it's been following us — orbitally speaking — because Earth has been leading the comet around the solar system racetrack in much the same way we're now leading Mars. Even as the comet falls behind our pace, it brightens gradually as it approaches its closest point to the Sun, or perihelion, in late February.

Glowing at 9th magnitude, this primordial snowball easily outshines the background galaxies near it in Pisces and resembles many of those in the fainter half of the Messier catalog. A 4-inch telescope at low power under a dark sky will bring the comet into view. Try to find it after February 15, once the bright Moon has taken its leave of the evening sky.

Bump up the magnification to 100x or so, and look for the comet's stubby tail. If you have trouble detecting it at first, search the side opposite the Sun's direction. The tail lies on that side because t e solar wind pushes comet dust outward. Don't forget that many scopes flip images.

Under a dark sky, you should notice a prominent naked-eye star pattern in this area: the Pisces circlet. The circlet's easternmost star, 19 Piscium, varies slightly in brightness and shines with a lovely deep-yellow to orange hue in small scopes.

## Sailing side by side

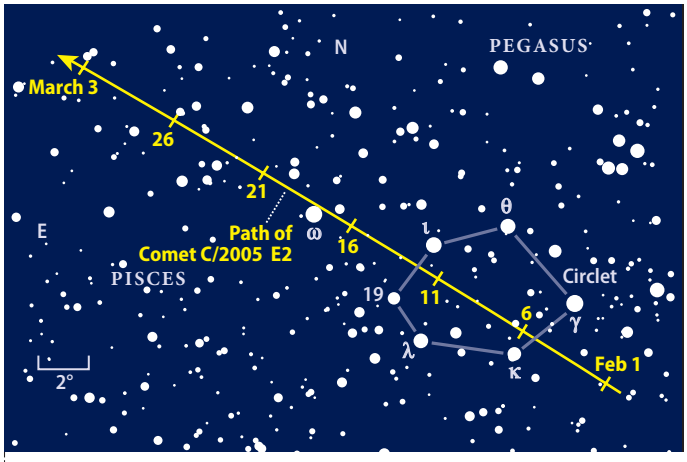
Occasionally, two asteroids lie near enough to each other that they can be viewed together. But rarely are two as close as this month's pair. For several nights in a row, 11 Parthenope and 16 Psyche keep within 2' of each other, less than 10 percent of the Moon's apparent size. Their proximity is just a line-of-sight effect, however. In reality, Psyche lies 15 million miles farther away than its apparent neighbor.

The red giant star Aldeba- [an th ruddy eye of Taurus the Bull, makes an easy starting point f r a star-hop to these space rocks. Both asteroids glow around 11th magnitude, similar to the many background stars littering the Taurus Milky Way. To be confident of a positive identification, photograph or make a sketch of the region and return to the same spot 2 or 3 nights later. The pair's movement should be obvious. Don't bother trying between February 4 and 10, when light from the c ar y Moon makes seeing the objects difficult.

## A brighter pair

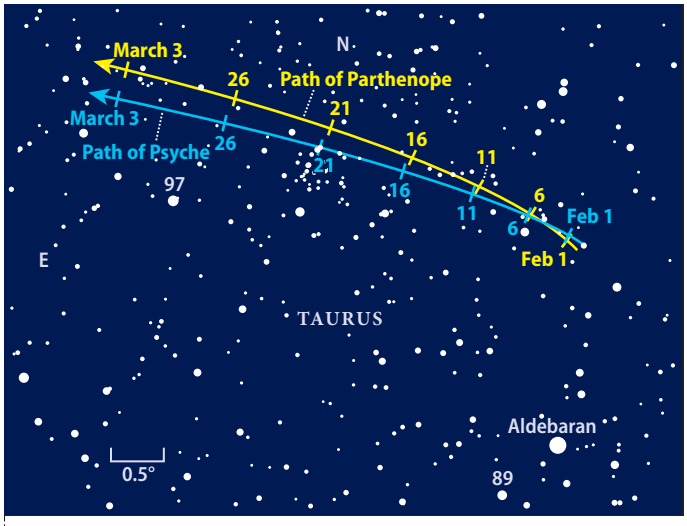
Two other, brighter asteroids are worth tracking this month, even thoug th y ,o li to each other. Asteroid 4 Vesta reached opposition January 5, so it spends February high in the evening sky. Although it has faded slightly to 7th ma nitude since opposition, it should still be easy to spot through binocu- ne t lars from a rural site. It's probably too faint to see from a suburban backyard without the help of a small scope. Throughout February, it remains the fifth-brightest object in the field of Epsilon (ε) Geminorum. You can find it with the help of the chart on page 57.

Another large asteroid, 3 Juno, shares this general area of sky. Juno glows at 9th magnitude this month as it makes a beeline for Orion's head.




ASTRONOMY: ROEN KELLY

**COMET C/2005 E2 (McNAUGHT)** should brighten to around 9th magnitude this month. This brings it within range of a 4-inch scope under a dark sky.



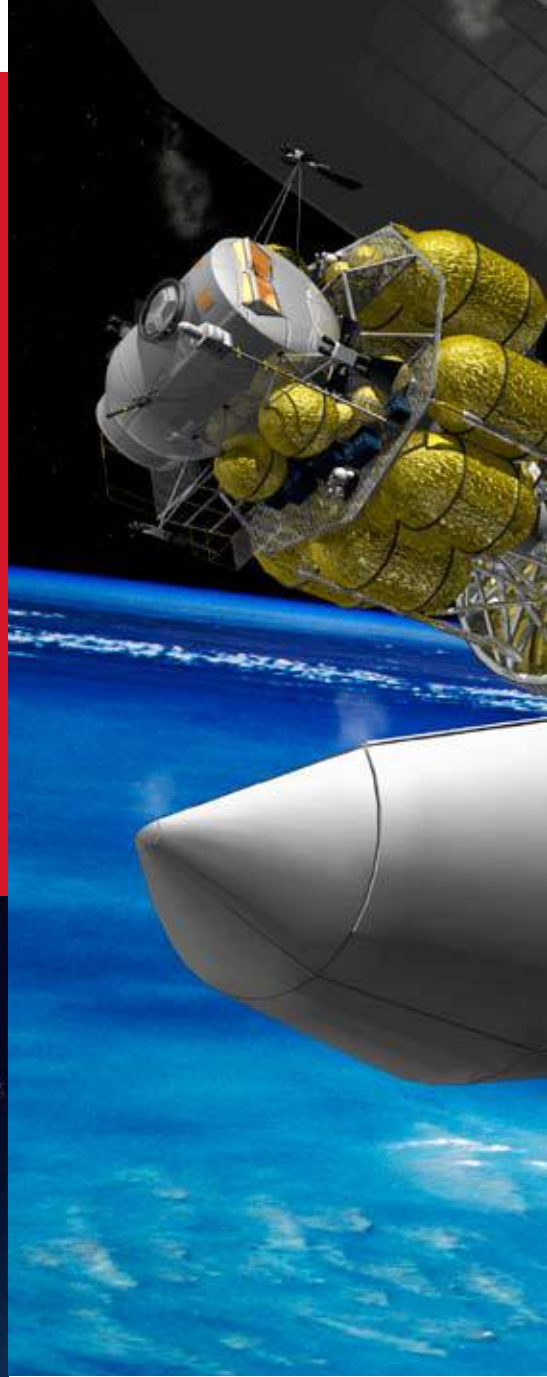

ASTRONOMY: ROEN KELLY

**ASTEROIDS PARTHENOPE AND PSYCHE** fly in formation during February, coming within 2' of each other early in the month against the rich stellar background of Taurus.

# NASA's next giant leap

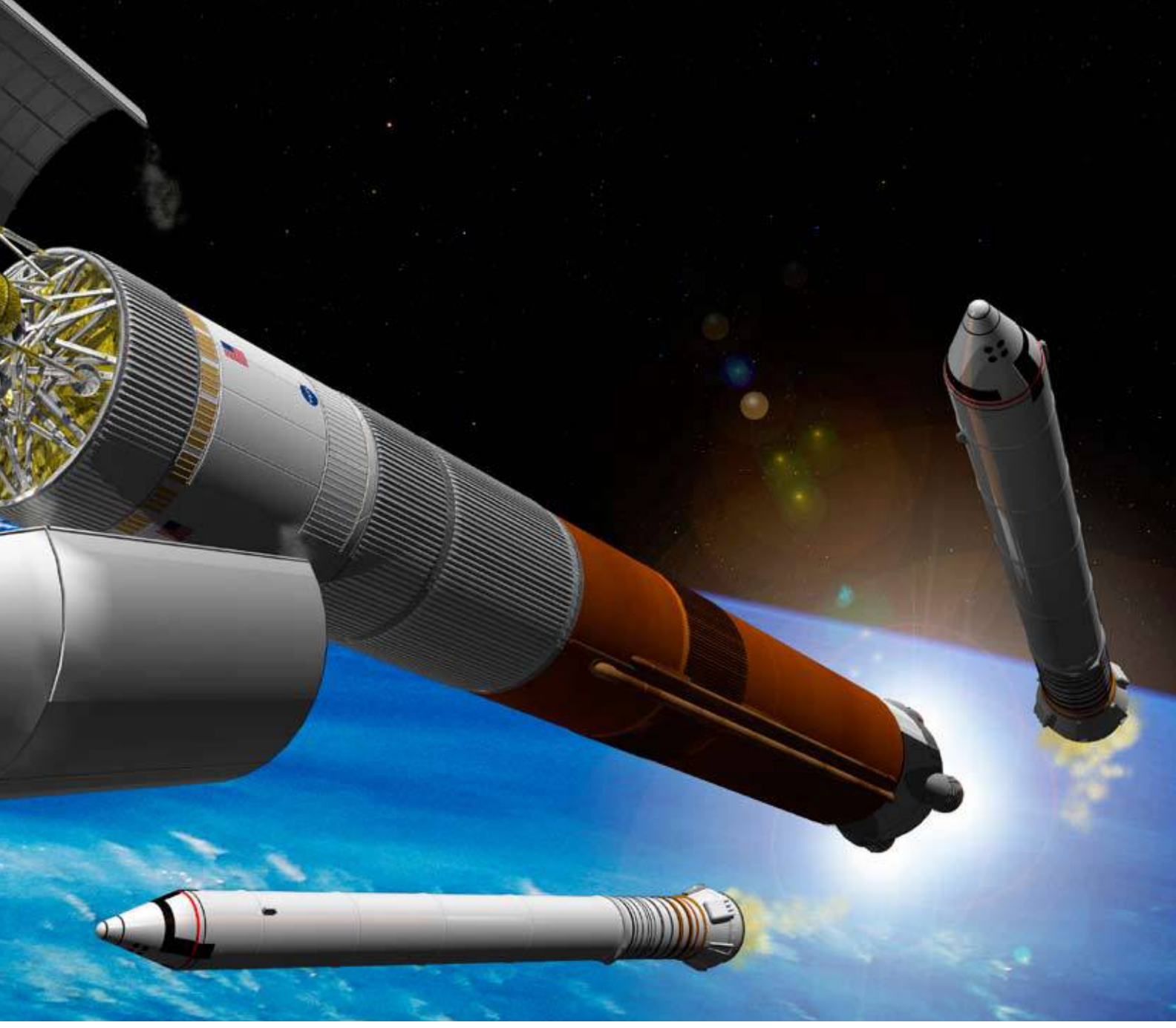
With plans for new spaceships and launch vehicles, NASA envisions a permanent presence on the Moon. ///

BY FRANCIS REDDY



▲ **A MAMMOTH ROCKET derived from space-shuttle components will blast into Earth orbit in 2017. Shortly after liftoff, the payload shroud will jettison and reveal the Lunar Surface Access Module, the vehicle that will deliver astronauts to the Moon's surface.** NASA/JOHN FRASSANITO & ASSOCIATES

◀ **THE SHUTTLE'S successor, the Crew Exploration Vehicle, heads into space. NASA's new spaceship will improve safety by combining the legacy of the Apollo program — a capsule with a launch escape system — with the most reliable elements of the space shuttle's launch system.** NASA/JOHN FRASSANITO & ASSOCIATES



NASA has finally pulled back the curtain on its strategy for human space flight once the space shuttle is retired in 2010. The agency's approach combines the most reliable elements of the Apollo and shuttle programs to create safer and more versatile spacecraft and launch systems. As outlined, the program will land astronauts on the Moon by 2018. But while the plan is widely seen as good rocket science, its $104 billion price tag is leaving some with sticker shock.

President Bush announced a new direction for the U.S. space program January 14, 2004. His vision involves completion of the International Space Station (ISS) and retirement of the space-shuttle fleet by 2010, to be followed by deployment of a new spacecraft called the Crew Exploration Vehicle (CEV). Although part of the CEV's job will be to ferry astronauts between Earth and ISS, its capabilities will extend far beyond Earth orbit. "This will be the first spacecraft of its kind since the Apollo Command Module," Bush said.

"The president put out a very bold vision," says NASA Administrator Michael Griffin, "the best mission statement NASA has had for 40 years, to be honest." But it was up to NASA's Exploration System Architecture Study (ESAS) to work out a system that dovetails current needs, like supplying ISS, with the goals of Bush's Moon-Mars initiative.

## Apollo redux?

"We only get one opportunity every generation to build a new space vehicle," says John Connolly, deputy lead for ESAS, and there are a lot of jobs the CEV needs to perform. Its first tasks would be to move crew and cargo to ISS, but it also has to be

**Francis Reddy** *is an associate editor of* Astronomy.

**A CREW EXPLORATION VEHICLE and its solar-powered service module (foreground) approach the International Space Station.** NASA/JOHN FRASSANITO & ASSOCIATES

/// EVERYTHING OLD IS NEW AGAIN

**WERNHER VON BRAUN originally preferred a rendezvous method of getting to the Moon similar to what NASA now proposes.** NASA

## FLASHBACK

Two months after NASA opened for business in October 1958, the agency's first administrator, T. Keith Glennan, began looking for a booster development plan. On December 15, he met with a group headed by Wernher von Braun, who led missile development at the Alabama Ballistic Missile Agency in Huntsville. The theme of von Braun's presentation — piloted lunar landings.

The team described five techniques for getting to the Moon and back: direct ascent, and four types of rendezvous en route. Direct ascent required a new heavy-lift rocket von Braun called the Juno V. He envisioned it with 7 stages, using different propellants in each, but feared the giant might be too ambitious. Instead, he preferred launching a number of smaller rockets and assembling them into a spaceship capable of reaching the Moon.

Ultimately, the Juno V morphed into the Saturn V, and the Apollo program went to the Moon using von Braun's direct-ascent method. — *F. R.*

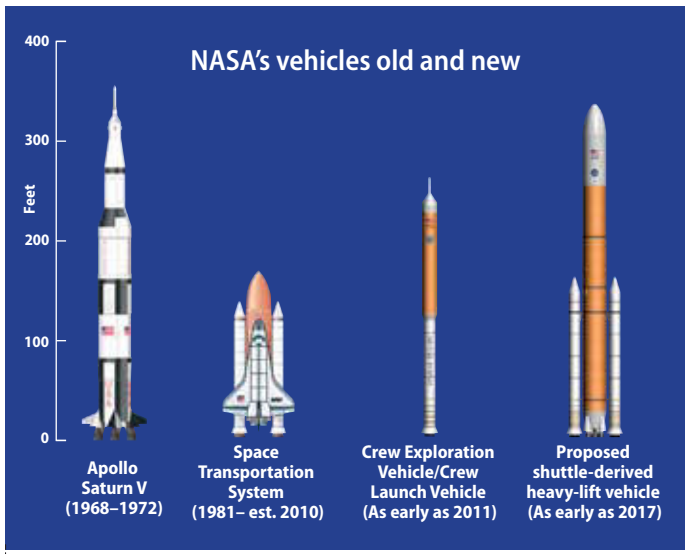
capable of missions to the Moon and, down the road, play some role in a trip to Mars. "Maybe we'll do other missions we haven't even thought of," he says. The CEV looks like an Apollo Command Module, only about 30-percent larger. It's a blunt body about 18 feet (5.5 meters) across at the base with cone-shape walls sloping 32.5° upward. "Think of it as Apollo on steroids," Griffin says. "In the course of this summer study … we really proved once again how much of it all the Apollo guys got right."

Why re-use a 40-year-old design? It has proven itself, and engineers will be able to tap the enormous volume of test data generated during Apollo's design phase. "Much of it looks the same, but that's because the physics of atmospheric entry haven't changed recently," Griffin says. But the CEV design will incorporate four decades of improvements in materials, electronics, and software.

The spacecraft has a blunt bottom that will carry a disposable heat shield to protect returning astronauts from the intense heat of re-entry. Connolly says NASA hopes the spacecraft itself will be reusable up to 10 times, but an exact figure will have to wait until the final design. Griffin envisions different CEV versions, or "blocks," each with increased crew and cargo capabilities. A Block 1 CEV could carry three astronauts to the space station, while a Block 2 CEV might carry four astronauts to the Moon.

Parachutes will slow the spacecraft for a gentle landing, but, in a change from Apollo, NASA wants the CEV to return to dry land somewhere on the U.S. West Coast. Leading contenders for the landing technology include airbags and retrorockets, and the standard landing site may be Edwards Air Force Base in California. The vehicle's design will include a capacity for Apollo-style splashdowns, but making them the exception rather than the rule means NASA won't have to maintain a dedicated recovery fleet. And a splashdown, which would expose the craft to corrosive seawater, would complicate any potential reuse.

As with Apollo, a cylindrical service module will supply the CEV's electrical and life-support needs. But unlike its predecessor, the CEV's service module will sport twin 4.5-kilowatt solar arrays — a first for a piloted American space vehicle. NASA expects to rotate space-station crews every 6 months and would like to rotate




NASA/JOHN FRASSANITO & ASSOCIATES

**NASA'S NEW VEHICLES derive from predecessors. Both the Crew Launch Vehicle and the proposed heavy-lifter will use Solid Rocket Boosters and Space Shuttle Main Engines.**

**THE MOONBOUND** Crew Exploration Vehicle and lunar lander lead the way as the heavy-lifter's Earth Departure Stage lives up to its name. NASA/JOHN FRASSANITO & ASSOCIATES

crews at a future lunar outpost with the same frequency. "So, we wanted to design a vehicle that would be able to loiter for up to 6 months [in lunar orbit] waiting for that crew to return," Connolly says. Solar panels constitute the only practical power technology.

Apollo's service module and lunar-lander engines used hypergolic fuels, which were considered the most reliable because they ignite when mixed. "However, they are not the highest-performing propellant combination that we have," Griffin explains. They're also toxic and dangerous to handle, and moving away from these fuels would increase safety for ground crews. So, when the CEV astronauts fire up the service-module engine, they'll be burning liquid oxygen and methane. When setting down on the Moon, the new lunar lander, called the Lunar Surface Access Module (LSAM), will use liquid oxygen and hydrogen, the most efficient propellants known. For liftoff, the LSAM's ascent stage uses the same engine and fuel as the service module.

Bottom line: This isn't your father's Apollo. "We're talking about … a CEV capsule that weighs about 50-percent more than the Apollo Command Module but can carry twice the number of people [and] … sustain itself for 6 months in lunar orbit," Griffin sums up. "It offers quite a lot more capability." Plans call for the CEV's first crewed launch by 2012, but there's said to be a quiet push for 2011 within NASA as the shuttle's retirement looms.

## Candlestick to space

While the CEV borrows heavily from the Apollo program, its rocket, the Crew Launch Vehicle (CLV), takes its cues from the space shuttle. "We took the most well understood and most reliable parts of the shuttle — the four-segment Solid Rocket Booster (SRB) … and the Space Shuttle Main Engine (SSME) itself — and those became the two core components for the vehicle that's going to lift the CEV into orbit," Connolly explains.

The study also addressed two of the shuttle system's shortcomings by placing the CEV atop the launch vehicle, where falling ice or insulating foam cannot reach it. "And on top of that, literally, we put a launch escape system much like the Apollo Saturn V had, so if there is any problem with anything below you, that … system can pull you away," Connolly says. "So, the combination of using the most reliable parts of the shuttle, using a very robust and simple and safe CEV design, and using a launch escape system, gives us a ride to and from space that's … probably … 10 to 20 times as safe as the existing shuttle."

The CLV will use a standard, reusable SRB as its first stage. The second stage, which is expendable, will use liquid oxygen and liquid hydrogen as propellants and a single SSME as the engine. The full vehicle, in its current concept, will stand 290.4 feet (88.5m) tall.

"I would ride this new booster with confidence," says Thomas Jones, a former astronaut who flew on four space-shuttle missions. "A factor of 10 increase in crew safety seems within reach — a significant increase over what the [space-shuttle] orbiter, even with upgrades, could ever provide."

Getting to the Moon requires something extra, so NASA plans include a heavy-lift launch vehicle derived also from shuttle components. Capable of hurling 125 metric tons into low Earth orbit, this monster will be a worthy successor to the Saturn V that sent the Apollo space missions toward the Moon.

Although the vehicle will support lunar voyages, Mars missions are what drive its massive scale. Any such trip requires a spaceship

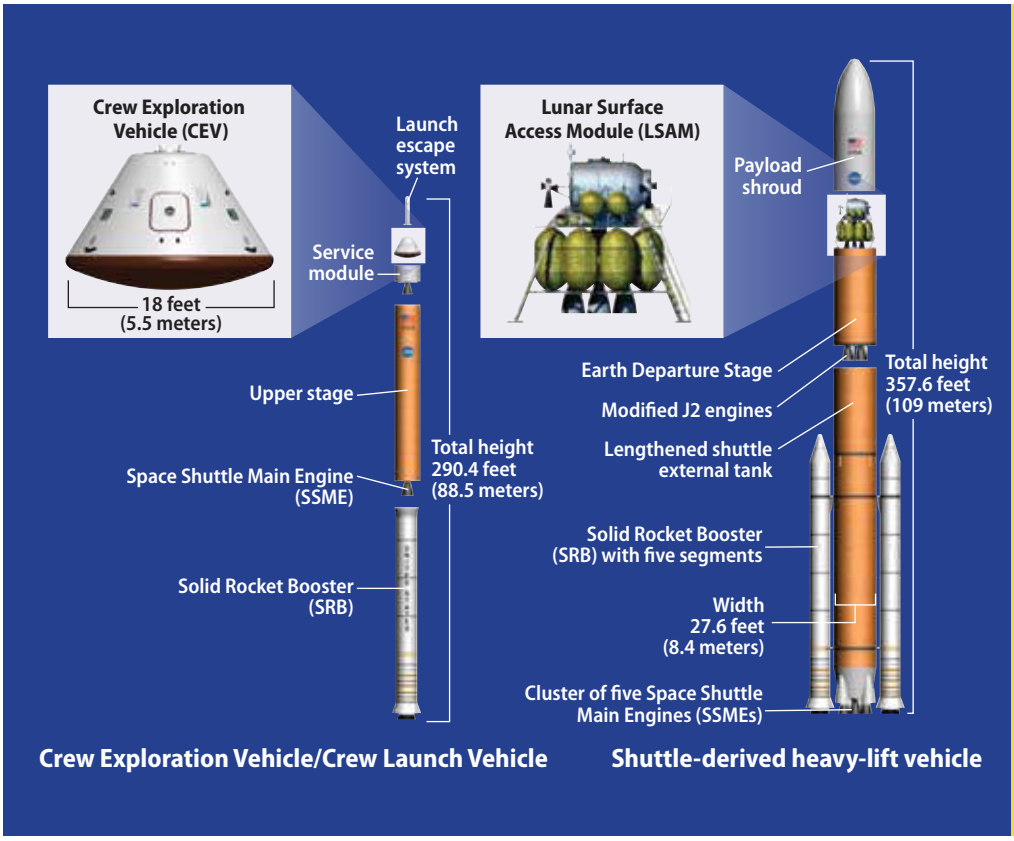
**AFTER ENTERING** lunar orbit, the crew enters the Lunar Surface Access Module and prepares to land on the Moon's surface. The lander can support a four-person crew for 7 days. The Crew Exploration Vehicle, which is left untended, can support itself for up to 6 months. NASA/JOHN FRASSANITO & ASSOCIATES

that can provide astronauts with food and life-support for a 6-month journey from Earth to Mars, plus carry a vehicle capable of bringing the crew home. These requirements alone point to the need for a vehicle too large to launch from Earth's surface. But the proposed shuttle-derived heavy-lift vehicle easily could loft several 100,000-pound (220,000 kilogram) components for orbital assembly. "We started with the requirement for what we would have to do to get to Mars and worked backward," Griffin says.

The heavy-lifter would be built from two reusable, five-segment SRBs attached to a longer version of the space shuttle's current external tank, which would be filled with liquid oxygen and liquid hydrogen. Five SSMEs would be located at the first stage's base.

An upper stage would use two modified versions of the J2 engines found in the Saturn V's second and third stages; like their predecessors, they'll burn liquid oxygen and liquid hydrogen. NASA calls this the Earth Departure Stage because it will provide the power to escape Earth orbit and head for the Moon. Griffin says NASA won't begin development of the heavy-lifter until the CLV is completed, which means the giant rocket won't make an appearance until about 2017.

A Moon mission as now envisioned would begin with a launch of the LSAM lunar lander into Earth orbit aboard the cargo vehicle. Astronauts would launch within a month on a CEV/CLV, rendezvous and dock with the lander attached to the Earth Departure


Crew Exploration Vehicle (CEV)
18 feet (5.5 meters)
Launch escape system
Service module
Upper stage
Space Shuttle Main Engine (SSME)
Solid Rocket Booster (SRB)
Total height 290.4 feet (88.5 meters)
Crew Exploration Vehicle/Crew Launch Vehicle
Lunar Surface Access Module (LSAM)
Payload shroud
Earth Departure Stage
Modified J2 engines
Lengthened shuttle external tank
Solid Rocket Booster (SRB) with five segments
Width 27.6 feet (8.4 meters)
Cluster of five Space Shuttle Main Engines (SSMEs)
Total height 357.6 feet (109 meters)
Shuttle-derived heavy-lift vehicle

## AFTER THE SHUTTLE

The new Crew Launch Vehicle/Crew Exploration Vehicle combination could begin ferrying astronauts and cargo to the International Space Station as early as 2011. The Crew Launch Vehicle will combine a four-segment space-shuttle solid rocket booster (SRB) with a newly developed liquid-fueled upper stage.

The shuttle-derived heavy-lifter will appear on the scene around 2017. It will use a pair of five-segment SRBs coupled with a liquid-fuel booster that's a longer version of the space shuttle's external tank. A new Earth Departure Stage will carry cargo — such as a lunar lander — into orbit. Once astronauts dock with the lander, the Earth Departure Stage would send them on to the Moon. NASA/JOHN FRASSANITO & ASSOCIATES

NASA/JOHN FRASSANITO & ASSOCIATES

▲ **ONCE ON THE MOON,** astronauts will seek out resources like water. By leaving behind hardware, NASA hopes to build a lunar outpost capable of supporting a permanent presence.

NASA/JOHN FRASSANITO & ASSOCIATES

▶ **ASTRONAUTS** lift off the Moon in the lander's ascent stage.

Stage, and blast toward the Moon. The Earth Departure Stage is jettisoned when its fuel is exhausted, and the CEV/LSAM combination continues to the Moon. Once there, the crew fires the CEV service module's engine and slows the craft so it enters lunar orbit. The entire crew of four astronauts then boards the lander, which separates from the CEV and sets down on the lunar surface. Astronauts' first lunar stay, called a sortie mission, could last as long as 7 days — more than double the surface time clocked on Apollo 17, which now holds the record.

## To the Moon and beyond

NASA's new plan makes the entire Moon available for astronauts. "We wanted a system that could get to any point on the lunar surface and return at any time," Connolly says. The Apollo landings were limited to the Moon's equatorial regions on the side always facing Ear h, and only during specific departure windows could astronauts blast off the lunar surface. "If we choose to leave at any time during the sortie mission, we can," he adds.

While astronauts could remain on the surface up to a week in the LSAM, Connolly explains, "The idea, of course, is to use the sortie missions to start deploying infrastructure to eventually put an outpost together." The descent stage of the LSAM remains behind, so it's an ideal place to leave hardware to support later missions. Even a portion of the lander's crew cabin may be left behind. "As you accumulate infrastructure, you should be able to extend the time you stay," he says.

At the end of their lunar visit, astronauts will board the lander and blast off in its ascent stage, leaving the descent stage behind. They'll then rendezvous and dock with the CEV, transfer to it, cast off the lander's ascent stage, and head for home. Once at Earth, the CEV will separate from its service module, which will crash into the Pacific Ocean. The CEV then will land in the United States.

Use of local resources, such as lunar ice, is a major focus because astronauts could drink reclaimed water or break it down to make air and fuel. NASA calls this In Situ Resource Utilization, or ISRU, and has made it a core component of current plans. Over the next few years, robotic surveys will scope out resource-rich lunar real estate that may serve as future landing sites.

NASA/JOHN FRASSANITO & ASSOCIATES

**FLOATING EARTHWARD** after re-entry, the crew prepares for a landing on solid ground at Edwards Air Force Base, California.

What if there is no ice on the Moon? Some think the next best place to look is on near-Earth asteroids, which NASA's vision also places within reach. "The architecture NASA has outlined is fully capable of going to these close-by objects," says Thomas Jones. Moreover, he notes, exploring asteroids may provide more germane experience for eventual Mars missions than a lunar outpost.

As for the cost, Griffin says the plan is a "go-as-you-pay architecture." The plan is "adjustable and adaptable" to fit the agency's congressional funding each year. A 2018 return to the Moon assumes constant funding at today's levels; getting there on less money simply will take longer.

For many, the best message coming from NASA is that the nation is now intent on building the systems needed to deliver safe and reliable human access to space, and to resume human exploration beyond Earth orbit. "We went to the Moon when I was 14," Jones says. "After nearly 40 years, it's time for another generation of young Americans to draw again on that powerful inspiration." A

**ONLINE EXTRA** Come to www.astronomy.com/toc for a look at the lunar locales scientists most want astronauts to explore.

Massive, energetic stars carve out voids in space and produce some spectacular targets. /// BY STEVE GOTTLIEB

# How to observe cosmic bubbles

**In 1867, Paris Observatory astronomers Charles Wolf and Georges Rayet uncovered a mystery they could not solve. While scanning the constellation Cygnus with a visual-prism spectroscope, they discovered three 8th-magnitude stars with strange spectra. More than** a century later, the nebulae surrounding a handful of similar objects — dubbed Wolf-Rayet (WR) stars — make outstanding deep-sky targets for amateur astronomers.

What caught Wolf and Rayet's eyes in the three stars' spectra were broad, bright emission lines. (Most spectra show dark absorption lines.) The nature of these emission lines was puzzling, and here's why: One of the strongest lines was due to the element helium — which wouldn't be discovered until it was seen in the Sun's spectrum the following year.

It wasn't until the last few decades that astronomers figured out where Wolf-Rayet stars fit in the life cycle of stars. Multi-wavelength research in infrared, radio, ultraviolet, and X ray — as well as visible light — has revealed Wolf-Rayet stars represent a late evolutionary phase in the lives of luminous, massive stars. These short-lived supergiants are rare — the *Seventh Catalogue of Galactic Wolf-Rayet Stars* (2001) lists a mere 227 members.

During the stable phase of a hot, massive star, a fast but tenuous stellar wind plows into the interstellar medium, sweeping away the ambient material and creating an interstellar bubble. Depending on its initial mass, the star will evolve into either a red supergiant or a luminous blue variable star. In either case, mass loss continues, forming a dusty circumstellar nebula inside the larger interstellar bubble.

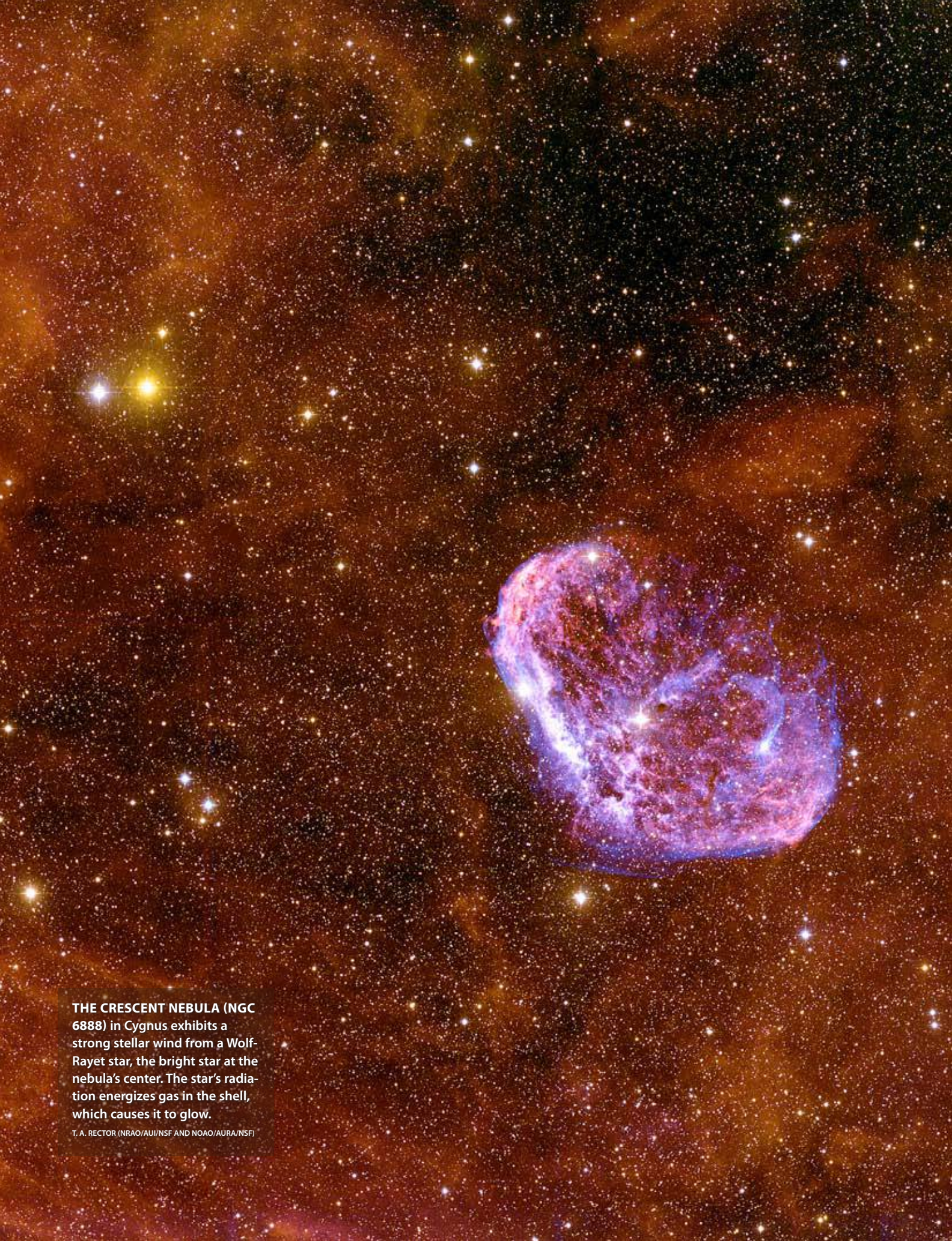
As the star further evolves into the Wolf-Rayet stage, a powerful stellar wind of up to 6 million mph (10 million kilometers per hour) ejects the star's outer envelope, which slams into the surrounding interstellar medium, and sculpts a beautiful shocked shell of ionized gas. The freshly exposed core equals between 10 and 20 solar masses and has a surface temperature between 25,000 and 60,000 kelvins. Extreme cases approach 90,000 K.

Wolf-Rayet stars' spectra show strong, broad emission lines. This implies copious amounts of ionized helium, carbon, oxygen, and nitrogen in their rapidly expanding envelopes. Two main subgroups are identified by their spectra. Strong nitrogen (N) emission lines characterize WN stars, while WC stars have strong carbon (C)

RICHARD CRISP

**SHARPLESS 2–157 in Cassiopeia is an emission nebula energized by an intensely hot Wolf-Rayet star. Although the nebula spans more than the width of the Full Moon, it's surprisingly easy to observe because it has a high surface brightness.**

**Steve Gottlieb** *has observed 9,000 deep-sky objects during the past 25 years under the dark skies of northern California.*



**THE CRESCENT NEBULA (NGC 6888)** in Cygnus exhibits a strong stellar wind from a Wolf-Rayet star, the bright star at the nebula's center. The star's radiation energizes gas in the shell, which causes it to glow.

T. A. RECTOR (NRAO/AUI/NSF AND NOAO/AURA/NSF)

DANIEL VERSCHATSE

**NGC 6357 is a stellar-wind-blown complex in Scorpius driven by the Wolf-Rayet star HD 157504. Open star cluster Pismis 24 lies just below the nebula's brightest part.**

lines. These classes may represent different phases in the evolution of Wolf-Rayet stars. One possibility is that WN stars develop into WC stars.

What's the fate for Wolf-Rayet stars? Due to their mass and advanced evolutionary stage, they are strong supernova candidates. We may have witnessed one such event March 29, 2003, when NASA's High Energy Transient Explorer (HETE-II) detected the powerful nearby gamma-ray burst GRB 030329. According to UC-Santa Cruz astronomer Stan Woosley, this event heralded the first direct link of a gamma-ray burst with a violent supernova. The likely progenitor of this explosive event was a Wolf-Rayet star.

## Bubbles through the eyepiece

The best-known Wolf-Rayet nebulae are the **Crescent Nebula** (NGC 6888) in Cygnus and **Thor's Helmet** (NGC 2359) in Canis Major. These two observing targets are favorites among amateur astronomers, but I wanted to track down other, lesser-known Wolf-Rayet shell nebulae.

Regardless of aperture, the key to viewing these celestial bubbles is to maximize contrast. So, observe under a dark sky, use a wide-field telescope/eyepiece combo (one with a 45' or larger true field of view), and use a narrowband nebula filter.

**Sharpless 2–308** is a huge Wolf-Rayet bubble easily located 15' north of 16 Canis Majoris. With my 17.5-inch reflector at 62x, a dim glow 35' to 40' across fills most of the field of view. An OIII filter transforms this ghostly nebula into a visual delight with a prominent 20' scalloped edge forming the western border. A brighter patch lies along the north side. On the south end, the nebula bends east, crosses through the center of a trio of magnitude 8 stars, and then passes just south of 16 CMa. A bit west of center is the massive WR star responsible for sculpting this celestial bubble. EZ Canis Majoris is a variable star that ranges from magnitude 6.71 to 6.95.

### /// OBSERVE THESE WOLF-RAYET BUBBLES

| Name | Right ascension | Declination | Wolf-Rayet star | Spectral type | Size |
|---|---|---|---|---|---|
| Sharpless 2–308 | 6h54m | –23°56' | HD 50896 | WN | 40' |
| NGC 2359 | 7h19m | –13°13' | HD 56925 | WN | 27' |
| NGC 3199 | 10h17m | –57°55' | HD 89358 | WN | 22' |
| HD 92809 nebula | 10h42m | –58°46' | HD 92809 | WC | 30' |
| NGC 6357 | 17h25m | –34°12' | HD 157504 | WC | 40' |
| NGC 6888 | 20h12m | 38°21' | HD 192163 | WN | 17' |
| Sharpless 2–157 | 23h16m | 60°28' | HD 219460 | WN | 50' |

Thor's Helmet is faint but visible in a 4-inch scope, while an 8-inch mated with a narrowband filter reveals a fascinating, high-surface-brightness structure. A 5'-wide bubble illuminated by Wolf-Rayet star HD 56925 forms the central "helmet," although I'm drawn to a brighter rim along the west side that creates a distinctive "C."

Through my 17.5-inch, the bubble has a complex structure with a tangled nest of irregular knots, faint streaks, and looping arcs of nebulosity. At the south end of the helmet, a bright 4' bar juts west of a 9th-magnitude star. This extension narrows into a 10'-long streamer of nebulosity forming the southern "horn" of the helmet. The matching horn extends northwest of the center. A thin filament begins on the north end of the bubble and shoots 10' due east.

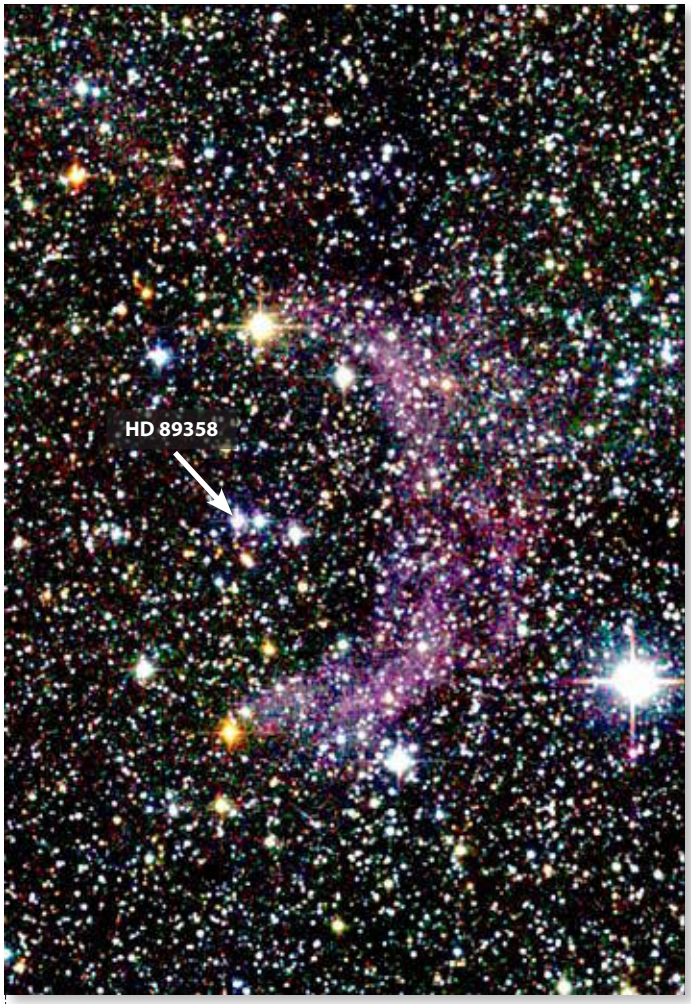
Wolf-Rayet star HD 89358 illuminates emission nebula **NGC 3199**. This bubble lies 4° northwest of the Eta Carinae Nebula (NGC 3372) in a rich Milky Way star field. It's bright enough to be visible through a 2-inch finder scope under a dark sky.

Through an 18-inch scope, NGC 3199 appears as a fairly bright, thick crescent roughly 10' by 6' and opening toward the east. The surface looks irregular and mottled through a UHC filter, appearing brighter on the south end near a pair of embedded stars. Low-surface-brightness haze extends off the main crescent toward the southwest and increases the total length to 15'. In size and structure, NGC 3199 is similar to the Crescent Nebula.

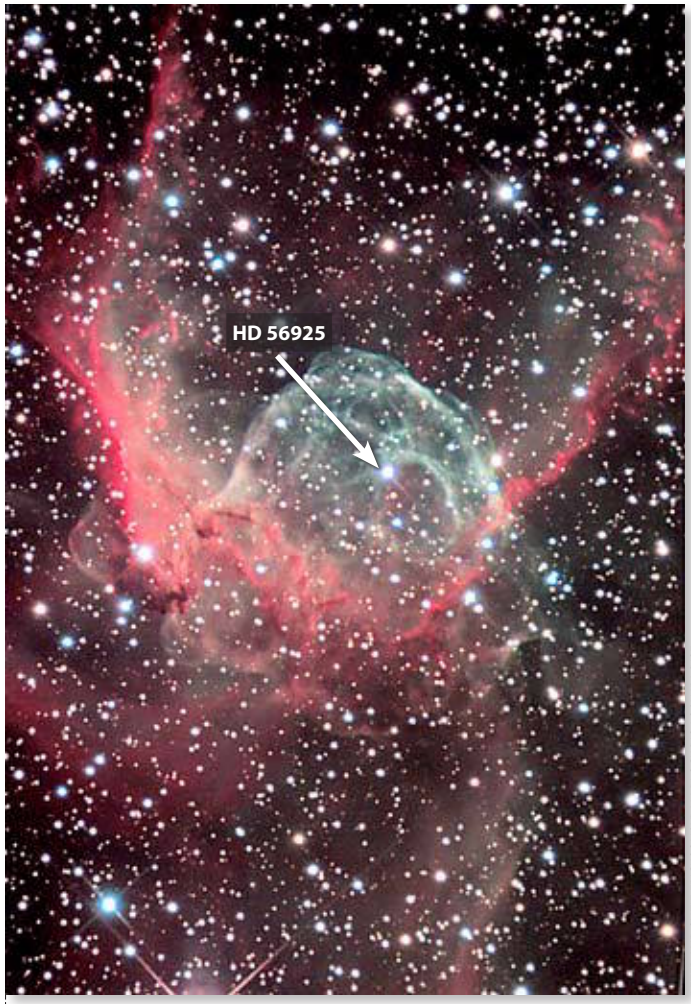
The Eta Carinae Nebula is home to several Wolf-Rayet stars, although it can be difficult to distinguish possible Wolf-Rayet bubbles against the high-surface-brightness mix of the region's nebulosity. Nevertheless, in 1980, a group led by French astronomer Marie-Claire Lortet identified a ring-shape, filamentary nebula at the north edge of the Eta Carinae Nebula surrounding the 9th-magnitude Wolf-Rayet star **HD 92809**.

I found a huge, broken ring, nearly 40' in diameter, centered on this star. The brightest sections are a narrow north-south crescent on the west side, a wide east-west arc of nebulosity forming the southern rim, and an isolated 4' by 3' oval patch to the southeast. Using an 8-inch scope from a dark site, you should be able to ferret out this little-known nebula.

Find **NGC 6357**, a stellar-wind-blown complex in southern Scorpius, by heading north along a ½° trail of four equally




**NGC 3199 in Carina is the windblown partial "ring" around the Wolf-Rayet star HD 89358, leftmost of the three blue stars left of center. NGC 3199 lies about 11,700 light-years from us. WR stars represent the final evolutionary stages of very massive stars.**




**THOR'S HELMET (NGC 2359) is a bubble powered by the Wolf-Rayet star HD 56925. Rapidly moving material ejected from the star interacts with surrounding hydrogen and carves out the distinctive shape, which glows because of the star's intense radiation.**

spaced 6th- and 7th-magnitude stars. English astronomer John Herschel discovered NGC 6357 in 1837 from South Africa's Cape of Good Hope. He found a "milky nebulosity, 2' by 1.5', close to and almost involving a double star." A 6-inch scope reveals a faint glow just north of the magnitude 9.6 open cluster Pismis 24. In the 17.5-inch, NGC 6357 appears as a distinct, high-surface-brightness slash roughly 4' by 1.5' in an east-west orientation. When I added an OIII filter, the surrounding field appeared weakly luminous, which increased the nebula's size to 30'.

The northern showpiece of Wolf-Rayet bubbles is the Crescent Nebula. Through a 6-inch telescope, you'll glimpse a faint arc of nebulosity passing through two stars of magnitudes 7 and 8. Through 10-inch and larger scopes, the Crescent Nebula comes to life. A few years back, I had a memorable view through my 17.5-inch reflector while at an altitude of 8,200 feet (2,500 meters) in California's Lassen National Park.

Under a dark, transparent sky, the entire 18' by 11' annulus appeared as a huge cosmic egg embedded in a rich Cygnus star field. The irregular rim is thickest on the southwest side but brightest to the north, where several knots and wispy tendrils are located. The large weakly glowing interior has an irregular surface brightness and contains an isolated bright knot. On this night, wispy striations radiated from the central magnitude 7.4 Wolf-Rayet star HD 192163 toward the northwest edge of the rim. The intricate structure gave a three-dimensional feel to the nebulosity.

**Sharpless 2–157**, a filamentary ring, sits 1° southwest of the Bubble Nebula (NGC 7635). (Despite its name, the Bubble Nebula results from stellar wind given off by a non-Wolf-Rayet star.) Sharpless 2–157 is a sprawling complex surprisingly easy to observe using an OIII filter through an 18-inch reflector. At 63x, a huge gossamer arc spans 35' by 8' in a rich star field and compares to one of the main strands of the Veil Nebula (NGC 6992–5) in a small scope.

Markarian 50, a compact open cluster, is a knot of 10 to 15 stars at the west edge of the nebula and is home to the magnitude 10 Wolf-Rayet star HD 219460. Near the arc's southern edge, an isolated 3' knot surrounds a double star whose components shine at magnitudes 11 and 13.5. A second, ill-defined river of nebulosity flows north-south about 20' west of the cluster. The sections merge at their southern extremities.

Now it's your turn to head out and observe bubbles — the results of some of the most energetic stars known. The brightest of these pose no problem for observers. The fainter ones, however, classify as challenge objects. Exercise patience, and you'll have no problem. Good luck!

# ASK ASTRO

*Astronomy*'s editors and experts from around the globe answer your questions about the cosmos. This month: determining Xena's orbit, spacecraft on Venus' surface, and what causes lunar halos.

PUZZLING ORBIT

**Q: How was the 10th planet's orbit established when it was observed for only a short time?** — **DICK SWARTWOUT,** PENN LAIRD, VIRGINIA

**A:** The first calculation of a newly discovered transneptunian object's (TNO) orbit is essentially a guess.

It's sometimes possible to obtain a reliable result (from observations on a single night) for an object zooming close to Earth. And astronomers can make a comparable computation for an asteroid in the main belt, between Mars and Jupiter, as it moves a few Moon-diameters relative to the background stars over the course of several nights.

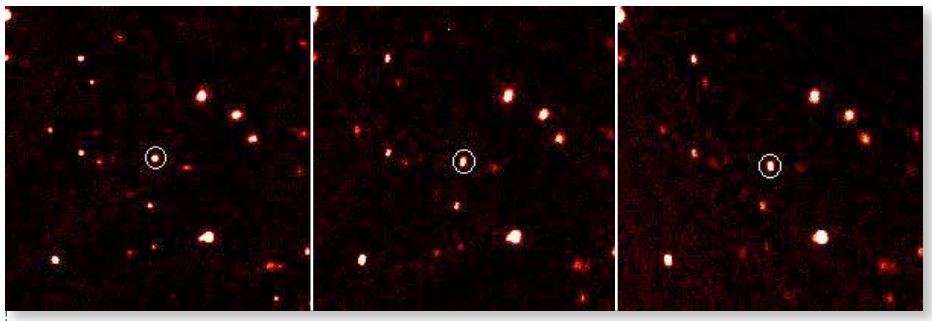
However, the slow across-the-sky movement of **a distant object usually requires astronomers to observe two successive oppositions** in order to determine and follow an object's orbit.

But even if the orbit is a guess, a typical TNO orbiting the Sun will move only a Moon-diameter roughly every year. Usually, a careful search will recover the object.

In the case of 2003 $UB_{313}$, the discovery team observed the 18th-magnitude object over an arc of sky extending little more than a single Moon-diameter during 6 weeks beginning in September 2003 and on three consecutive nights in January 2005.

Based on these positions, a computed orbit conclusively showed the object is near its farthest point, 97 AU from the Sun, and has an orbit with a period of 550 years and inclination of 44° to the ecliptic.

Once astronomers knew where it was, they could determine where it had been. Astronomers searched for earlier observations on sky surveys. The oldest known images of 2003 $UB_{313}$ were identified on plates exposed as part of the original Palomar survey in September 1954. In fact, these images were made using the same telescope (Samuel Oschin 48-inch) that was used to discover the object. — **BRIAN G. MARSDEN,** HARVARD-SMITHSONIAN CENTER FOR ASTROPHYSICS, CAMBRIDGE, MASSACHUSETTS



**THE 10TH PLANET, circled, moved slightly in these images taken 90 minutes apart October 21, 2003. Not until January 5, 2005, did Mike Brown — lead discoverer — realize this object had moved.** SAMUEL OSCHIN TELESCOPE, PALOMAR OBSERVATORY

LANDING ON VENUS

**Q: How many spacecraft have landed on neighboring Venus, and is there anything left of them by now?** — **JIM CHICKERING,** GEORGETOWN, MASSACHUSETTS

**A: Twelve probes have survived the trip to the broiling surface of Venus.** Ten were Soviet landers, eight of which were part of the Venera series. The cores of the Venera probes consisted of 8-foot-diameter (2.4 meter) pressure vessels. The bases were doughnut-shape cushions. Although each craft's initial descent was slowed by parachutes, the last moments relied on metallic plates above the landers that caused enough drag in the dense atmosphere to slow the craft.

In 1970, Venera 7 became the first spacecraft to land on Venus' surface. It returned signals for 35 minutes as it fell through the atmosphere, and another 23 minutes from the surface. Two years later, Venera 8 also made it down, surviving the blistering heat for nearly an hour. Both Venera 7 and 8 measured surface temperature and pressure.

The first surface images came to us from Venera 9 and, shortly thereafter, Venera 10 in 1975. The Venera 9 landing-site panorama shows a sloping field of eroded volcanic rocks. Venera 10 landed 3 days later, about 1,370 miles (2,200 kilometers) away, and returned images of a more eroded landscape with rounded rocks on dark soil.

In 1978, NASA's Pioneer Venus Multiprobe mission sent four probes into the venusian atmosphere. Two of them made it to the surface, and one survived for 70 minutes after it landed. Venera 11 and 12 made landfall the same year. Several instruments failed, and no images were transmitted due to defective lens caps. (Both Venera 9 and 10 had twin cameras, and each lander had one lens cap that did not jettison. Apparently, the "fix" made the problem worse for Venera 11 and 12).

The landers discovered electrical discharges in the atmosphere similar to lightning. Studies since have indicated lightning may crackle through the clouds 35 miles (56 km) above the surface.

More surface panoramas came back from Venera 13 and 14 in 1982. Both cameras on each lander worked, allowing for

dramatic 360° panoramas. Both also carried an arm to drill into the soil.

The final Soviet Venus missions were the most spectacular. The Vega 1 and 2 missions (with international collaboration from the French) dropped off landers and balloons on their way to Comet Halley in 1986. Vega 1's instruments were inadvertently turned on at 12.4 miles (20 km) above the surface — due to buffeting by a strong wind gust — and did not return data from the surface. Vega 2 returned atmospheric *and* surface data. The balloons lasted nearly 2 Earth days until they drifted into the morning Sun. Then, as expected, they popped.

What's left of these exp orers? The sulfu ric acid rain that falls from venusian skies probably does not make it to the ground, but circulates as a gas. The surface pressure would have little visible effect on the landers. Winds are fairly slow at the surface, although there may be some erosion from windblown grains of dust and sand.

Temperature has the greatest effect. While most of the Venera landers were metallic, thermal blanketing covered the tubes that carried refrigeration liquid into the craft. Other blankets wrapped portions of the main pressure vessel itself. These may well be peeling away.

Additionally, a color strip designed to calibrate color photos taken by the cameras would have faded almost immediately in the heat. Heat-resistant ceramic was switched, at the last minute, to a cheaper material that would have turned brown in the oven-like temperatures on Venus. But overall, the Veneras may still be in good shape — especially considering their environment.

**— MICHAEL CARROLL,** SPACE ARTIST AND AUTHOR, LITTLETON, COLORADO

RONNIE WARNER

**A LUNAR HALO is a fantastic sight. Without optical aid, our eyes are not sensitive enough to break the ring into separate colors. Because a camera gathers more light than our eyes, a quick photograph will capture the halo's details. Here, two 3-second images were stacked.**

LUNAR HALOS

## Q: Occasionally, especially on cold winter nights, I see a large ring around the Moon. What causes this? — CHRISTINA GUSEMAN, CHARLOTTESVILLE, VIRGINIA

A: Spying a bright Moon with a ring around it high in a cold winter sky is a beautiful, and even spooky, sight. But you can spot Moon halos any time of year — and the same phenomenon occurs with the Sun, and from the same cause.

Moon halos occur when **you see the Moon through a sheet of randomly oriented ice crystals high in the atmosphere.** Ice crystals have a hexagonal shape and take two forms. One is columnar and resembles an unsharpened golf score-sheet pencil. The other form is plate-like and mimics a hexagonal bathroom-floor tile.

To produce a Moon halo, light passes through one side of the pencil-like crystal and emerges from another side. It makes two refractions and is deflected 22° from its original path. The refraction has the effect of concentrating light rays around the Moon 22° away from it, or about as far as a hand held at arm's length can spread. The ring has a width of about 1.5°, or 3 Moon-diameters.

Because the light passes through the crystals, each acts as a tiny 60° prism, splitting the moonlight into colors. The most visible color is a reddish tinge seen on the ring's inner edge, which is more sharply defined than the outer edge. Because the ice crystals are not optically perfect prisms, ring colors seldom appear vivid or intense.

In the case of the tile-like crystals, light can pass through one flat face and one side, being bent 46°. This creates a different ring about twice as far away from the Moon (or Sun). The 46° halos, however, are fainter and seen less often. Still, whenever you spot a 22° halo, take a look farther out for the wider halo. (Try covering the Moon or Sun with your thumb.) Observers who check out the sky frequently usually catch sight of 22° halos at least a few times a month. The 46° halo is a lot less common.

The meteorological condition most likely to produce halos is an approaching warm front. This occurs when warm, moist air is lifted over a layer of colder air. As the leading edge of the warm air mass moves overhead, its high, thin ice clouds can produce the halo. Later, when the bulk of the warm air mass lies closer to you, clouds are generally too thick to produce a halo, and rain (or snow, depending on season) is probably in your forecast. Thus, the old wives' tale of halos around the Moon or Sun foretelling rain in 12 to 24 hours has some grounding in truth. **— ROBERT BURNHAM,** MARS SPACE FLIGHT CENTER, ARIZONA STATE UNIVERSITY

*Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.*

Now is the time to find the most elusive terrestrial planet. /// BY MICHAEL E. BAKICH

# Catch Mercury at its best

## Five planets are visible to the naked eye. Of these, Mercury is the most difficult to see. Indeed, many amateur astronomers have never seen Mercury. During the last half of February, however, the innermost planet will put on its best evening show of the year. Mercury

orbits the Sun at an average distance of only 36 million miles (58 million kilometers). Earth is nearly 3 times as far from the Sun, so, from our perspective, Mercury always stays near the Sun.

When Mercury is as far east of the Sun as it can get (called greatest eastern elongation), we see it as an evening star low in the west. When it's west of the Sun, we view it as a morning star in the east before sunrise.

Some elongations are better than others because of Earth's tilt and the stretched-out nature of Mercury's orbit. Even at its farthest apparent distance from the Sun, Mercury appears no more than 28° away. At a "bad" elongation, the planet may be as little as 18° from the Sun.

But the numbers above give only the planet's angular distance from the Sun. For observers to see Mercury easily, the Sun's apparent path through our sky — called the ecliptic — has to be nearly at a right angle to the horizon. This position places Mercury higher in the sky than when the ecliptic/horizon angle is shallow.

Mercury's best evening appearance this year begins February 8, when the planet lies only 10° from the Sun in Aquarius the Water-bearer. Then, Mercury sets 45 minutes after sunset and shines at its brightest, magnitude –1.4, during this elongation. Look for Mercury through binoculars 30 minutes after sunset. You'll need an unobstructed western view and a clear sky right down to the horizon because the planet stands only 3° high at this time.

After February 8, Mercury appears 1° higher in the sky each night. At greatest elongation, it reaches a maximum of 11° above the horizon 30 minutes after sunset February 23 and 24. Its elevation comes with a price, however. When Mercury appears highest, it keeps only 43 percent of its maximum brightness: magnitude –0.5.

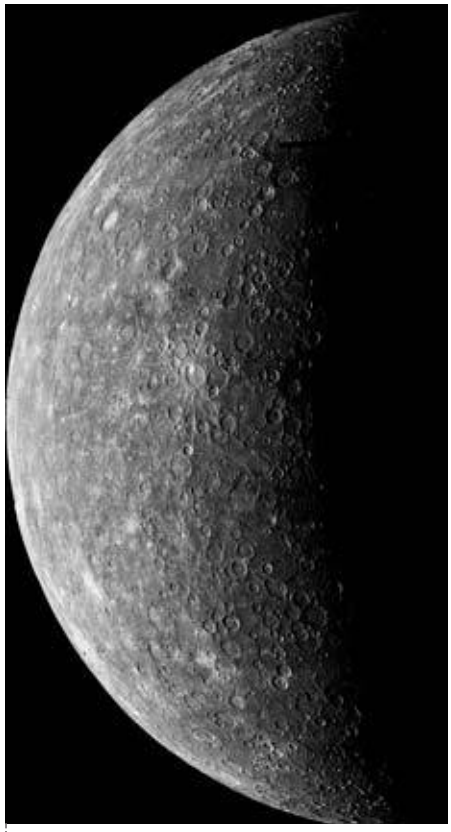
Let's hope weather allows viewing Mercury on or before its greatest elongation. After February 24, the planet dims nightly. On March 1, it glows at magnitude 0.3 — only 17 percent as bright as at maximum.

**Michael E. Bakich** *is an associate editor of* Astronomy.

/// STATISTICS

**MERCURY**

| | |
|---|---|
| **Diameter** | 3,030 miles (4,880 kilometers) |
| **Average distance from the Sun** | 35,980,000 miles (57,910,000 km) |
| **Year** | 87 Earth days 23.3 hours |
| **Day** | 58 Earth days 15.5 hours |
| **Angular size** | 10" (max.); 4.9" (min.) |



NASA/MARK ROBINSON

**MERCURY looks bland from Earth, showing little detail besides a small disk and changing phases; but spacecraft reveal a heavily cratered world.**

Through a telescope, Mercury disappoints. Its disk appears small — only 7" across at greatest elongation. It never climbs high, so when you observe Mercury, you're looking through the most distorting part of Earth's atmosphere.

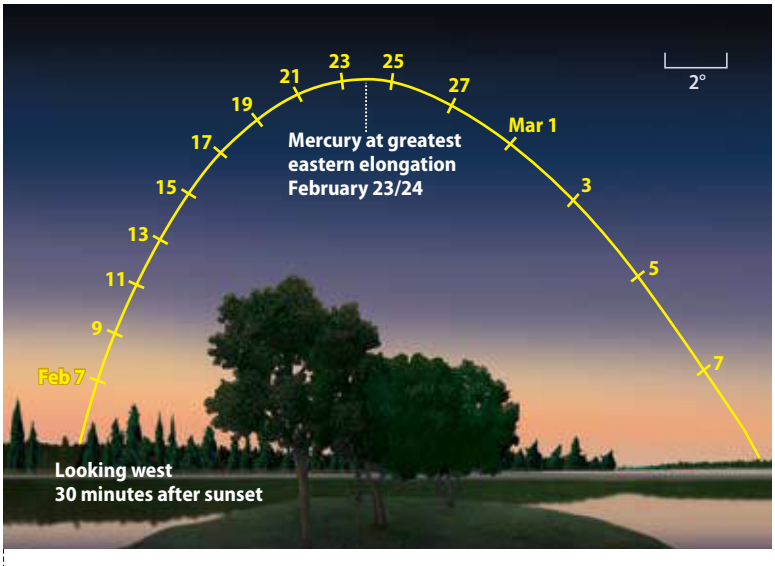
You can address the distortion problem in a way that may sound strange to beginning amateur astronomers — observe Mercury during the day, when it appears higher

**UPCOMING ELONGATIONS OF MERCURY**

| | | | | |
|---|---|---|---|---|
| **Evening** | June 20, 2006 | October 17, 2006 | February 7, 2007 | June 2, 2007 |
| **Morning** | April 8, 2006 | August 7, 2006 | November 25, 2006 | March 22, 2007 |

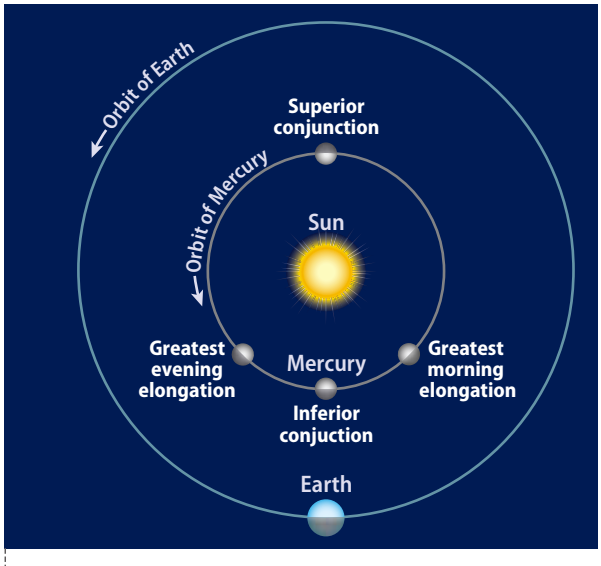
**MERCURY** met with the crescent Moon at 6:45 A.M. EDT September 2, 2005. The waning Moon was only 1.57-percent illuminated when this shot was made from Dayton, Ohio.

JOHN CHUMACK




ASTRONOMY: ROEN KELLY

**MERCURY** appears best on or before greatest elongation. After that date, the planet appears fainter each night.




ASTRONOMY: ROEN KELLY

**AT GREATEST** evening elongation, Mercury appears east of the Sun, low in the western evening sky.

in the sky. Use caution when attempting this — the planet never strays far from the Sun. A go-to drive that you previously aligned and left on all day works well for this observation. (For advanced observers, if your telescope's mount has setting circles, use them to find Mercury's position by offsetting from the Sun's coordinates.) Use a red filter in the daytime to reduce the amount of scattered blue light.

Through your scope, expect to see Mercury go through phases similar to the Moon's. On February 8, the planet's disk will be more than 90-percent illuminated. At greatest elongation, Mercury's disk will appear half-lit, and it will shrink to a 23-percent-illuminated crescent by March 1.

Most observers detect no surface markings on Mercury. It takes a seasoned planetary observer and excellent atmospheric conditions to see anything at all on the planet, even through the largest amateur telescopes. Experienced amateurs have recorded dusky markings and occasional bright areas on the planet.

For most of us, however, just seeing Mercury in the evening sky counts as a successful observation. So bundle up, brave the winter air, and get ready to mark this planet off your "to see" list.

| | | | | | |
|---|---|---|---|---|---|
| September 29, 2007 | January 22, 2008 | May 14, 2008 | September 11, 2008 | January 4, 2009 | April 26, 2009 |
| July 20, 2007 | November 8, 2007 | March 3, 2008 | July 1, 2008 | October 22, 2008 | February 13, 2009 |

Today's watchmakers produce sophisticated time pieces that unite astronomy and art. /// BY RAYMOND SHUBINSKI

# Pieces of time

People told time for thousands of years by observing celestial objects. But in recent centuries, the trend has reversed. Man-made objects, such as watches, now tell us what time it is and — for astronomers — what time celestial objects will appear. Ironically, some of these down-to-Earth time pieces come with astronomical prices.

During the 19th century, the age of the pocket watch, the Swiss excelled at what was known as "full-calendar" watches. These instruments told the time, the day of the week, the number and name of the month, and even the phase of the Moon. In an era without radio or television, such a watch was practical as well as a mechanical work of art. By the 1920s, watchmakers had reduced these functions to the wristwatch.

A few Swiss firms still produce such watches: Patek Philippe, Maurice Lacroix, Jaeger-LeCoultre, Ulysse Nardin, Audemars Piguet, and IWC. Watch manufacturers outside of Switzerland also produce high-tech timepieces for astronomers.

**Raymond Shubinski** *is director of Science City/Attractions in Kansas City, Missouri, and a long-time watch collector.*

## Patek Philippe

Founded in Geneva in 1839, Patek Philippe produces some of the most complicated mechanical watches in the world. These pocket and wristwatches not only have the classic full-calendar functions, they also include such features as sidereal time — measured by Earth's rotation with respect to the stars (rather than the Sun); perpetual calendars — that automatically adjust for the varying lengths of months; the date of Easter; and rotating Northern and Southern Hemisphere star maps.

In March 2001, Patek Philippe came out with an even more complicated model — a double-sided wristwatch. The Sky Moon Tourbillon provides the many functions standard in Patek Philippe models. Like any mechanical watch, you must keep it wound, and selling the family farm may not net enough profit to buy one, if you can get on the waiting list. Only two of these models are made each year.

**A MASTERPIECE IN 12 MOVEMENTS,** **Patek Philippe's Sky Moon Tourbillon is a symphony of astronomy, art, and watchmaking ingenuity.** PATEK PHILIPPE

**THE SKY MOON TOURBILLON**
Price: About $750,000
**This watch by Patek Philippe comprises 694 parts and presents the nocturnal sky on its reverse. Patek Philippe produces only two of these models a year.**
PATEK PHILIPPE

## Maurice Lacroix

Another Swiss firm, Maurice Lacroix, makes the Masterpiece Lune Rétrograde. This watch — a direct descendant of the full-calendar pocket watch of a century ago — has a beautiful mechanical movement visible through a transparent back. It also boasts a full-calendar display and a Moon-phase dial. With this watch, you will always know the best time to observe.

## YES watch

If this all still seems a bit rarefied, we can come back down to Earth to find watches that provide a great deal of information at prices any amateur astronomer can afford. The YES watch is perhaps the most useful for astronomers.

Bjorn Kartomten designed the watch as a way to get in-sync with nature. The inspiration came to the Norwegian while visiting Machu Picchu. Kartomten wanted a watch that encompassed "natural" time — time based on the observation of natural events such as sunrise and sunset, Moon

T. A. RECTOR AND B. A. WOLPA/NOAO/AURA/NSF

phases, and the motions of the Sun and planets — and conventional time.

When the YES watch hit the market in 1999, it didn't take Kartomten long to realize he had created the ultimate watch for astronomers. By combining both digital and analog displays with a proprietary chip, this watch is an astronomical computer ready to be strapped to your wrist.

At first glance, it looks bulky and unconventional. The current models, the Inca and Zulu, are made entirely of titanium, which makes the watch comfortable to wear. Just one hand circles the dial every 24 hours. To supplement the hour hand, an LCD display on the upper part of the dial provides the current time. Below that is a Moon-phase indicator.

The "shading" on the dial also shows how much daylight and darkness to expect each day. The watch can be customized to your exact longitude and latitude. Do you need to know the time for a second city on a regular basis? Just set the "Away" time as a second location.

But what if you need to call your aunt in Sydney? With a push of two buttons, you scroll through nearly 600 preset cities. The information scrolls quickly, so it takes little effort. Once you pick your new location, the entire display resets to show all its information respective to the new city.

With the push of one button, the watch provides current sunrise, sunset, moonrise and moonset times, and the Moon-phase percentage. The instrument also presents calendar information.

Perhaps the most incredible aspect of this watch is an LCD "line" along the main dial's outer edge. At a glance, you can see the times of moonrise and moonset. The shade "wedge" of day and night will give sunrise/sunset. This watch gives a graphic representation of the most basic information all astronomers want: the Moon's location and its relationship to the Sun.

This watch's features even teach astronomy lessons. On the summer solstice, for example, use the preset on the watch for Sundsvall, Norway, to confirm the Sun will not set on this date. The YES watch also has alarms, timers, and other useful features you would expect from a quartz watch. It even has special "fireworks" displays for the solstices and equinoxes. All the unexpected features tie this watch to the cosmos in ways that make it unique.

**MASTERPIECE LUNE RÉTROGRADE**

Price: $18,250

**Maurice Lacroix celebrated its 30th anniversary by launching its Masterpiece Lune Rétrograde. The date display at 10 o'clock is a retrograde indication. A power-reserve indication at the 2 o'clock position presents information about the winding state of the main spring and reminds the wearer to wind the watch.** MAURICE LACROIX

**THE ZULU**

Price: $695

**YES watch's Zulu model gets its processing power from a microchip the size of a baby's fingernail. Algorithms collected from private astronomers, the U.S. Naval Observatory, and NASA were blended into a program that calculates extensive time data for the Sun and Moon through the year 2100.** YES WATCH

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**Tissot's High-T with MSN Direct enables wearers to receive news, weather, sports scores, stock updates, appointment reminders, and — just in case — the time.** TISSOT

## Tissot

Maybe your computer meets your astronomical needs, but you want to track metrological information from one observing site to the next. Certain watches provide this information. Several years ago, the Swiss firm Tissot introduced such cutting-edge technology in a wristwatch.

The Tissot T-touch watch provides important information for anyone who spends much time outdoors. The watch displays information in both analog and digital formats. By pressing one button, you activate a touch screen built into the dial.

You can access an altimeter, barometer, thermometer, alarm, timer, or compass. Simply touch the word around the edge of the dial, and the hands spin to point at your choice. The barometer gives the current reading, and the hands indicate if the air pressure has been rising or falling during the last 8 hours.

Science fiction takes over when you touch the compass indicator. The hour and minute hand separate to form a "needle" with the minute hand pointing north. As you rotate the watch, the hand continues to indicate true north. T-touch even adjusts for magnetic declination so you get a true north-south line. What a great tool for telescope setup!

Tissot has expanded its Tactile line to include other unusual watches. If you want an alarm that doesn't awaken your spouse as you slip out to view the early morning sky, the Silent-T can do the job. This watch has a built-in vibration system that provides alarms and time-telling by touch with no loud squeak. The new Navigator 3000 provides an extensive list of times for world cities, again with touch-screen technology.

Tissot introduced the High-T to this line. The High-T can link directly to Microsoft Network (MSN) on the Internet and provide everything from e-mails to stock quotes. Imagine getting real-time weather forecasts while on a hilltop observing site.

**THE PATHFINDER**
Price: $250 with resin band; $300 with titanium band
**Casio's Pathfinder offers an altimeter, thermometer, barometer, digital compass and stopwatch.** CASIO

## Casio

If the Tissot watches look high-tech enough for James Bond, Casio's Pathfinder belongs with the Special Forces. The Pathfinder incorporates an altimeter, barometer, compass, alarm, and thermometer.

Casio also makes watches for fishermen that give sunrise, sunset, and Moon-phase information. The Casio Forester has a calendar, time signal, backlit dial, sunrise/sunset timekeeper, age and phase of the Moon function, and even a vibrating alert (to avoid frightening the fish).

**THE VECTOR WRISTOP COMPUTER**
Price: $219
**This watch from Suunto combines an altimeter, barometer, and an electronic compass to make it an ideal watch for any outdoor enthusiast. Its compass lets the user correct the difference between true north and magnetic north.** SUUNTO

## Suunto

Suunto offers outdoor-adventure watches that adapt well to astronomy. Its Vector Wristop Computer provides many of the same functions as the Tissot T-touch in a purely digital format. The altimeter, barometer, and compass offer memory and log capabilities for this durable watch.

Suunto's X9 has a built-in GPS and can be linked to a laptop to upload/download information. Dick Tracy never had it so good!

## Blancpain

It's difficult to capture nature's rhythms with digital technology. Watchmakers have long sought to do so with mechanical devices. One of the most difficult cycles to show with a mechanical watch is the equation of time — a formula that accounts for the earliest sunrise occurring before the summer solstice and the latest sunset occurring after the summer solstice, but not by exactly the same number of days.

A watchmaking firm little known outside of the watch-collecting world, Blancpain, combined the motion of the true Sun — as it appears in the sky — with the standardized motion of the mean Sun.

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www.suunto.com

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www.blancpain.ch/e

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Front

**THE EQUATION MARCHANTE**
Price: $128,100
**The Equation Marchante from Blancpain has two coaxial minute hands that indicate mean solar time and real solar time, respectively. Users can visualize the discrepancy between nature's rhythms and the time adopted by modern society. Only 50 were made.** BLANCPAIN

If you observe a sundial for a year, you will see that sundial time runs fast part of the year and slow at others. This variation from clock time can be as great as 16 minutes, not accounting for daylight-saving time. The explanation for this discrepancy lies in Earth's elliptical orbit and tilt. Publications such as almanacs give correction tables so you can set the clock in your hallway using a sundial.

Blancpain's Equation Marchante combines these disparate cycles and packs them into a platinum case. Only 50 of these watches exist, and it's fair to wonder, why? With today's computer technology, information such as this is just a mouse-click away. The Blancpain watch transcends pure function and moves into the realm of artistry.

The watch dial provides the time of day and the equation of time, and boasts a perpetual calendar and Moon phase. The dial also is cut away at the 6 o'clock position so you can see the instrument's heartbeat.

The back of the watch is a visual feast. The movement is hand-engraved with the Sun, Moon, and a star seen under the protection of a sapphire crystal. Even if we can't own such a watch, we can at least dream of capturing the heavens in a platinum case.

### Sharpe Products

The great American poet Henry David Thoreau admonished his readers to "simplify, simplify, simplify." If you feel as if you should heed this call, and you have no desire to wind watches or change batteries, a traditional solution awaits.

More than 2 decades ago, Steve Sharpe received a postcard from a friend, Peter Payack, that depicted the ancient monument of Stonehenge on a pocket watch. Peter called it the "Gentleman's Timepiece" still ticking after 5,000 years!

"The idea was a great leap backwards in timekeeping," says Sharpe. As his invention shows, Sharpe was up to the task, and he soon reduced the megalithic structure to fit in his pocket. The Stonehenge pocket watch was born.

This bit of whimsy has evolved from a standard pocket watchcase to the current model in pewter or gold tone. Pop the lid to find a reproduction of Stonehenge.

This watch comes complete with a compass and small rod that fits in the center of the stone circle to become a portable sundial! It includes a small quartz watch in the outside lid for those who just can't break away from our standardized, homogenized, regulated time.

### Time for sale

As these watches prove, "Do you have the time?" is quite the loaded question:

*"For which city?"*

*"Natural time?"*

*"Do you want GPS coordinates with that?"*

From $50 to $1 million, you can find your ideal watch. Watches not only give you the time; but added luxuries can be time-savers. So, how much is your time worth?

**THE STONEHENGE**
Price: $42.95 (pocket watch only); $47.95 (with chain)
**Sharpe Products' Stonehenge preserves the timekeeping of antiquity with a small rod that fits in the center of the stone circle to become a portable sundial.**
*ASTRONOMY:* WILLIAM ZUBACK

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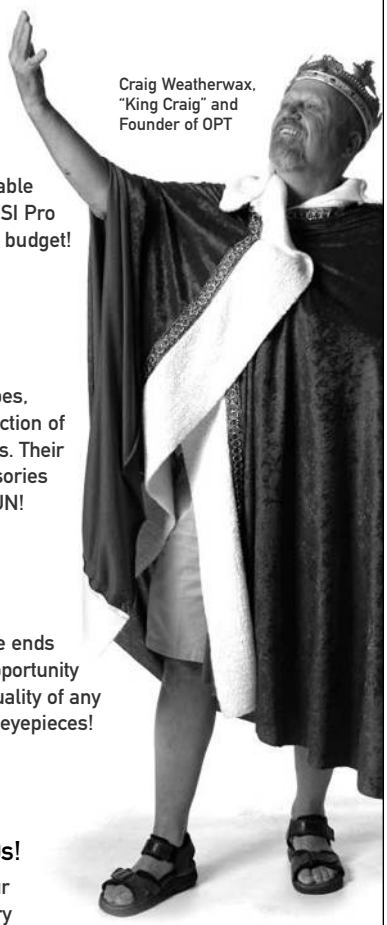

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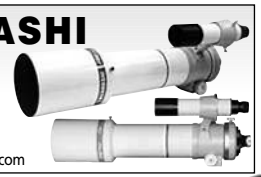

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## EQUIPMENT REVIEW

High-grade optics, excellent tracking, and unexpected features highlight Meade's RCX line of telescopes. /// BY ROBERT KUBEREK

# A 12-inch powerhouse

When a major manufacturer introduces a new telescope line with advanced optics, we notice. In 2005, Meade Instruments announced the RCX400 Advanced Ritchey-Chrétien automated telescope. How well does it perform? As I put it through its paces, I found its optical and mechanical quality to be top-notch, and I discovered new features not previously available on Meade's LX series scopes.

### What's in a name?

The new scope contains a spherical primary mirror. Meade claims this mirror, in combination with the telescope's front corrector lens, "looks like" a hyperbolic primary (such as those used in Ritchey-Chrétien [RC] telescopes) to the secondary mirror. The RCX400's design, therefore, is optimized for photography and promises the coma-free performance of an RC telescope at a much lower cost.

### Fit, finish, and setup

The 12-inch RCX arrived in two boxes: One weighed 134 pounds (61 kilograms) and contained the optical-tube assembly (OTA) and the base; the other weighed 66 pounds (30 kg) and contained the tripod.

The tripod legs are solid (each weighs about 15 pounds [7 kg]) and well-made. Each has an external compression ring with a tension bolt that can be tightened by hand. The leg slides around the tripod-base leg receptacle, and a quick-release lever engages a lock.

The fit and finish of the new RCX look good. The carbon-fiber tube boasts a distinctive, plaid pattern, a dramatic change from the older blue tubes. I rated the included 8x50 finder scope, SCT-to-2" adapter, 2" star diagonal, and 24mm Ultrawide eyepiece highly, especially the finder.

The RCX's optical-tube assembly is well-balanced, even with the accessories attached. You'll notice the set screw on the 2" diagonal sits close to the back. You won't be able to get your fingers around the set screw to tighten it when an eyepiece overhangs the rim of the diagonal, as it does with the supplied 24mm Ultrawide. Meade provides an extra-long set screw for use with such eyepieces.

Don't look for a manual-focus adjustment. The focuser works by moving the corrector and secondary along three rails with three motors. The focuser is quiet, smooth, and precise. Unfortunately, the space between the corrector assembly and the tube allows unwanted dust inside.

Automatic alignment works via the keypad menu system. Once initiated, the drive first finds home/level and then north.

I had difficulty aligning, however, because I didn't calibrate the sensors the first time I set up the scope. Do this, and your keypad won't report a "level north error" while trying to find north. The standard Two-Star Alignment worked as it always had on my Meade LX200.

The instruction manual is easy to follow but has no index. The tutorial format and clear instructions make it easy to learn the system. I found the discussion of drift-alignment easy to understand.

On the other hand, the mechanics of polar alignment are not explained fully. For example, during the Two-Star-Alignment procedure, you must know the positions of the right ascension slew stops. Position the mount halfway between the stops at the outset, or the procedure may abort.

In addition, the starting "home" position for the OTA in polar alignment seems upside down (the finder scope lies underneath the OTA). This may confuse some first-time users.

The scrolling readout on the keypad provides lots of easy-to-see information.

**THE OPTICS** in the RCX400 provide sharp observations of celestial objects across the entire field of view.

**ACTIVE COOLING** via the rear-mounted fan (top) is a new feature of the RCX line.

**Robert Kuberek** *is a dedicated visual observer and imager who lives in Valencia, California.*

**MEADE'S 12-INCH RCX400 delivers superb optical performance. This go-to telescope is a complete system that will keep even advanced amateurs observing — or imaging — for years.**

ALL PHOTOS: *ASTRONOMY*: WILLIAM ZUBACK

**THE 12-INCH RCX400** is a large portable telescope. Be sure you can handle the weight, or have someone help you with setup.

/// SPECIFICATIONS

## MEADE'S 12-INCH RCX400 ADVANCED RITCHEY-CHRÉTIEN

**Optical**
Focal length: 2,438mm
Focal ratio: f/8

**Weight**
OTA: 94 lbs (42.7 kg)
Tripod: 56 lbs (25.5 kg)

**Dimensions**
16.9" by 21.1" by 25.75"
43cm by 53.6cm by 65.4cm

**Also included**
- 24mm Series 5000 UWA eyepiece
- 2" star diagonal with 1¼" adapter
- 8x50 finder scope

**Price**
$6,799

**ACCESSORIES** included with the RCX400 are (left to right) a 26mm Ultrawide eyepiece, 2" to 1¼" adapter, and 2" star diagonal.

During the alignment procedure (whether alt-az or polar), the keypad essentially walks you through the process, providing scrolling commentary and advice.

Pointing is excellent: The drives move quietly, and the focuser works great. The focuser shows some backlash in fine and superfine modes. This may cause the focus at a given position to read differently depending on whether the mirror moves in or out. Be sure to run the backlash calibration procedure from the keypad.

## Under the stars

I observed with the 12-inch RCX400 in a variety of conditions during several weeks. Under light-polluted suburban skies, I observed Saturn, Jupiter, globular cluster M3, and some double stars.

Under darker country skies, I viewed globular clusters Omega Centauri and M13, and galaxies M101, M51, and NGC 6445. I used three of Meade's new Series 5000 Ultrawide eyepieces: the (supplied) 24mm, the 14.4mm, and the 8.8mm.

Jupiter looked sharp at 100x. M3 was fine in bright moonlight — well-resolved with pinpoint, rich-field-refractor-like stars. I split Castor easily. All stars appeared sharp, round, and undistorted nearly to the edge of the field.

When seeing turned a bit soft, I switched to observing the Moon. At 60x, detail and contrast were excellent and compared favorably with views through any unobstructed scope I've owned.

At the lowest magnification while observing the Moon, I noticed what I suspect is the secondary mirror's shadow. It wasn't enough to bother me, and I didn't detect it on any other object.

On a different night in better seeing, Jupiter showed nice color and definition at 100x. A transit of Io was in progress. The moon was bright and sharp just inside the edge of Jupiter's disk.

A little later, I noticed Io's shadow, black and well-defined. Io was as contrasty in the 24mm Ultrawide as I'd ever seen it in any scope, the shadow just a little less so.

Under darker skies but poor seeing, Omega Centauri appeared almost powdery only 6.5° above the horizon. M101 showed broad hints of spiral structure, and M51 showed clear spiral structure.

As with Jupiter, increasing the power on M13 did not cause image breakdown. The Box Nebula (NGC 6309) showed a definite lopsided, boxy shape with a darker interior, a view comparable to what I have seen through a 14-inch scope.

The RCX holds collimation (optical system alignment) well. In fact, it was well-collimated right out of the box. On the other hand, the RCX I tested showed a bit of spherical aberration when I defocused moderately bright stars.

I detected no color fringes at any power on bright stars, Jupiter (when centered), or the Moon. I saw slight color only on Jupiter when it lay at the edge of the field through the Ultrawide eyepiece.

## Equatorial setup

To get set for imaging, I installed the wedge on the tripod and did a rough polar alignment. I set the mount mode to "Polar," and after the initialization procedure finished, I put the scope in the "Home" position. In this position, the RCX400 should be pointing roughly at Polaris. Now, the scope seems to be upside down (the finder will be on the underside).

Next, I initiated the One-Star Alignment procedure. Using an illuminated reticle eyepiece (ordered separately), I worked the altitude and azimuth adjustments on the wedge to center Polaris in the eyepiece. The scope then slewed to Arcturus. I centered it and finalized the alignment.

To check the alignment, I did a go-to command for Jupiter. It wasn't dead center, but it was in the eyepiece at 100x.

The "Easy," "One-Star," and "Two-Star" Alignment procedures are approximate. Meade recommends you perform precise polar alignment using the drift method. If a star at the meridian and near the celestial equator drifts in declination, you need to adjust the azimuth. If a star at the horizon and near the celestial equator drifts in declination, then you need to adjust the altitude. I'd never done this procedure, but the instruction manual explains it clearly.

## Imaging

Astrophotography with the RCX400 is easy. I chose M3 for my first target. The mount flexed a little when I installed the camera, but M3 stayed in the field of view.

Of course, I couldn't hope the camera would be parfocal with the eyepiece I used. As an imager, the RCX really shines. The electric focuser is a dream to use. You get a digital readout of the focus position, which helps immensely with fine adjustments.

The RCX produces a curved field of view, which could cause softness at field edges. Meade is working on a field flattener, but I saw no evidence of any edge softness in my SBIG ST-10XME CCD camera's 14.9mm by 10mm field.

On the third evening of observing, the scope went out of collimation while focusing. I suspect a voltage issue, with one of the focusing motors slightly stiffer than the others because slewing had slowed. I had experienced slow slewing the second night also, but corrected this with new batteries.

A phone call to Meade confirmed this hunch. Installing new batteries fixed the focuser problem, but the factory default collimation setting was way off. I decided to test the collimation procedure.

Information on collimation appears in the keypad's setup/telescope menu. Options appear to "Collimate," "Restore default," and "Save to default." Select collimate, and the keypad gives you the choice of fast, medium, slow, and fine. Pressing an arrow key adjusts the secondary in a corresponding direction, moving the motors independently to achieve the adjustment. Because the tilting of the secondary moves the star out of the field, you must stop collimation, press the mode button to back up in the menu, re-center the collimation star, and re-enter collimation mode frequently while performing the procedure.

**MORE ACCESSORIES** included with the RCX400 are the 8x50 finder scope (left) and the Autostar keypad. The keypad functions as the computerized heart of the drive system.

The process was quick and painless: I nailed the collimation within seconds without touching the telescope or recruiting help. Because the factory defaults weren't correct for me, there was no need to keep them. I overwrote the defaults with the new current settings.

Beware of low batteries. If you must use them, I suggest changing them every couple of hours. Listen for audible slowing of normal slewing. This will warn you of a low-battery condition.

In low temperatures, batteries drain faster. I suggest ordering the AC adapter for this scope (sold separately) as well as the cigarette-lighter adapter (also sold separately). Order factory-approved power accessories or you risk voiding the warranty. After-market adapter plugs come in two polarities, and AC adapters are rated for differing amperages.

Of course, how accurately the mount tracks is crucial if your plans include astrophotography. For the RCX I tested, tracking out-of-the-box was acceptable (±5").

For CCD imaging, some combination of guiding and periodic error correction is probably necessary. For example, a CCD with 24 micron pixels combined with a tracking error of ±5" translates to ±2.4 pixels at the 2,438mm focal length of the RCX. Unguided and uncorrected, a tracking error of ±2.4 pixels will result in some elongation in star images unless you keep your exposures short.

The only complaint I have imaging with the RCX is the mount's stability. Even light breezes cause the scope to shake.

Once the mount starts to shake, it takes seconds (count of 10) to settle down completely. I couldn't tell where the shake originated, but I suspect the fork arms rather than the tripod or wedge. (Imagine a tuning fork's vibration when struck.)

/// COOLDOWN TEST

### TEMPERATURE CONTROL

SCTs are famous for cooling down to ambient air temperature slowly. The RCX contains a small fan behind the primary, which offers the hope of better thermal performance than Meade's LX series. The keypad also has options to read out both the ambient temperature and the tube's temperature in real time. One evening at 1,200-feet (365 meters) altitude with the fan on starting at 9 P.M., the RCX gave these readings:

| Time | Ambient temp. (°F) | Tube temp. |
|---|---|---|
| 9 P.M. | 64° | 68° |
| 10 P.M. | 61° | 67° |
| 11 P.M. | 57° | 66° |

On another night, this time at 5,200 feet (1,600m) altitude, the results were as follows:

| Time | Ambient temp. (°F) | Tube temp. |
|---|---|---|
| 7 P.M. | 71° | 75° |
| 8:15 P.M. | 59° | 66° |
| 9:20 P.M. | 50° | 62° |
| 11 P.M. | 40° | 59° |

## To buy or not to buy

All things considered, this scope more than lived up to my hopes. It is well-made, easy to use, and has high-quality optics.

Considering the size of the central obstruction, the RCX is a wonderful visual instrument, and initial tests suggest it has great promise for imaging. This scope delivers Ritchey-Chrétien-like performance at a fraction of the cost.

For visual observers and serious imagers who cannot afford, or do not wish to commit to, a Ritchey-Chrétien, the Meade RCX400 is worth a look. Just be sure you can handle the weight. A

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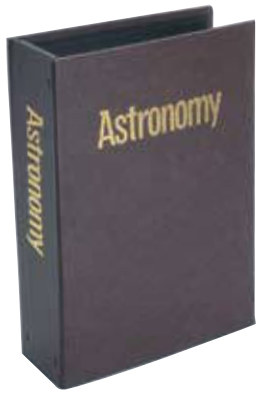


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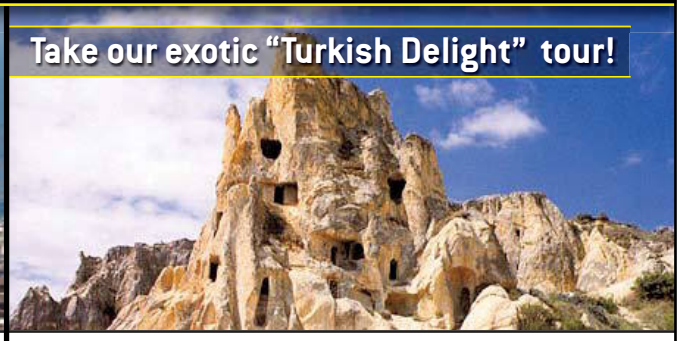

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APRIL 23–30

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the TSP is known for its no-nonsense observing atmosphere. To ensure this high-quality experience, attendance is limited to 700.

In addition to skywatching, activities include tours of McDonald Observatory, lectures, workshops, imaging, horseback rides, and a swap meet.

For more information, e-mail the TSP registrar at tspreg@texasstarparty.org; web site, www.texasstarparty.org.

JANUARY 27–28
### Death Valley Star Party
Furnace Creek Inn and Ranch Resort, Death Valley, California. Sponsored by the Las Vegas Astronomical Society, this event offers many alternatives to stargazing, including swimming, hiking, carriage rides, and golf. With spa treatments and gourmet meals, this isn't a star party for those looking to "rough it." For more information, e-mail Phyllis Nefsky at pnefsky@xanterra.com; web site, www.furnacecreekresort.com.

JANUARY 28
### Connacht Star Party
Westwood House Hotel, Galway, Ireland. Sponsored by the Galway Astronomy

Club (GAC), this 1-day event features observing, exhibits, lectures, and workshops. For more information, e-mail the GAC at info@galwayastronomyclub.ie; web site, www.galwayastronomyclub.ie.

FEBRUARY 22–26

## Deep South Texas Stargaze

Escondido Ranch, McMullen County, Texas. Hosted by the Kingsville Astronomical Society, this gathering is held under nearly 7th-magnitude dark skies. Climate-controlled bunkrooms with showers are available as well as camping and RV sites. In addition to observing, there will be speakers and door prizes. For more information, e-mail Jason Fry at dstsreg@hotmail.com, web site, raychamp1.tripodAcom/DSTS2006/dsts2006.html.

[illegible] EBRUARn 2h–26

## Orange Blossom Special Star Party

Alafia River State Park, Lithia, Florida. Although it is easily accessible from Tampa, this site offers extremely dark okies. There will be other family-oriented activities, [illegible] nctuding a h[illegible] y ide, music jam session, and group hike along the park's trails. No walk-ins will be permitted. For more information, call[illegible] 813.792.0721; e-m il, dnefarr@msn.com; web site, home1.gte.net/hoffmanc.

MARCH 3

## Tri Star

Guilford Techni al Community College, Jamettown, North Carolina. Cosponsored by the Cline Observatory ande Gree[illegible] sbory Astronomy Club, this event [illegible] eatu[illegible] [illegible] s speakers, prizes, and vendors. For more information, e-mail Tom English at tr[illegible] nglish@gtcc.edu; web site, technet.gtcc.cc.nc.us/comserv/cline.

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## Kitt Peak National Observatory iD Wo[illegible] k[illegible] hohs

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MARCH 17–19

## Mid-Atlantic Mirror-Makers Weekend

St. Jones Reserve, Dover, Delaware. This seminar will introduce novices to mirror-making techniques and practices. Emphasis will be placed on mirror figuration. All materials will be furnished, and expert mirror-makers will help guide each person. Attendees will leave the weekend with a fine-figured mirror, ready for aluminizing. They also will have the knowledge and skills to repeat the process. For more information, e-mail don.surles@verizon.net; web site, www.delmarvastargazers.org.

MARCH 31–APRIL 2

## South Pacific Star Party

Wiruna, near Ilford, New South Wales, Australia. Hosted by the Astronomical Society of New South Wales, this site offers great dark skies. The location is a nature-lover's paradise, featuring wombats, kangaroos, exotic birds, and other wildlife. For more information, visit www.asnsw.com/spsp.

MARCH 31–APRIL 2

## Tennessee Spring Star Party

Fall Creek Falls State Park, Pikeville, Tennessee. This is a beginner-friendly star party, and admission to this event is free. Surrounded by a large nature preserve, this site provides some of the darkest skies in the region. For more information, e-mail spsmith@bellsouth.net; web site, www.cumberlandastronomicalsociety.org.

### CONTACT INFORMATION

Please submit club announcements 4 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

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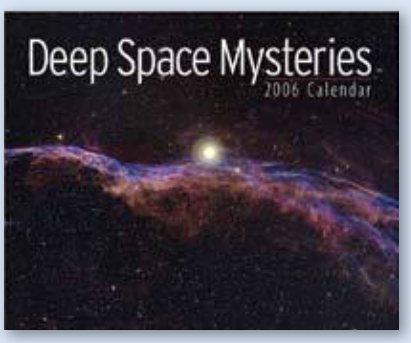

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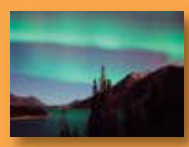

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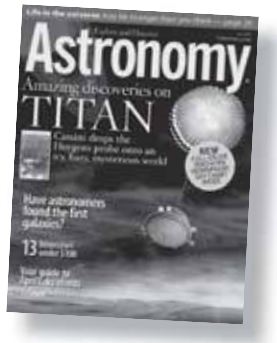


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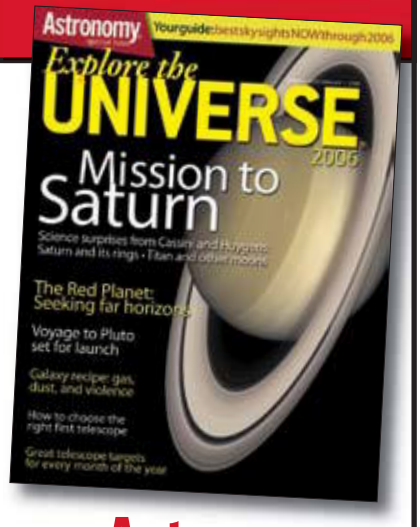


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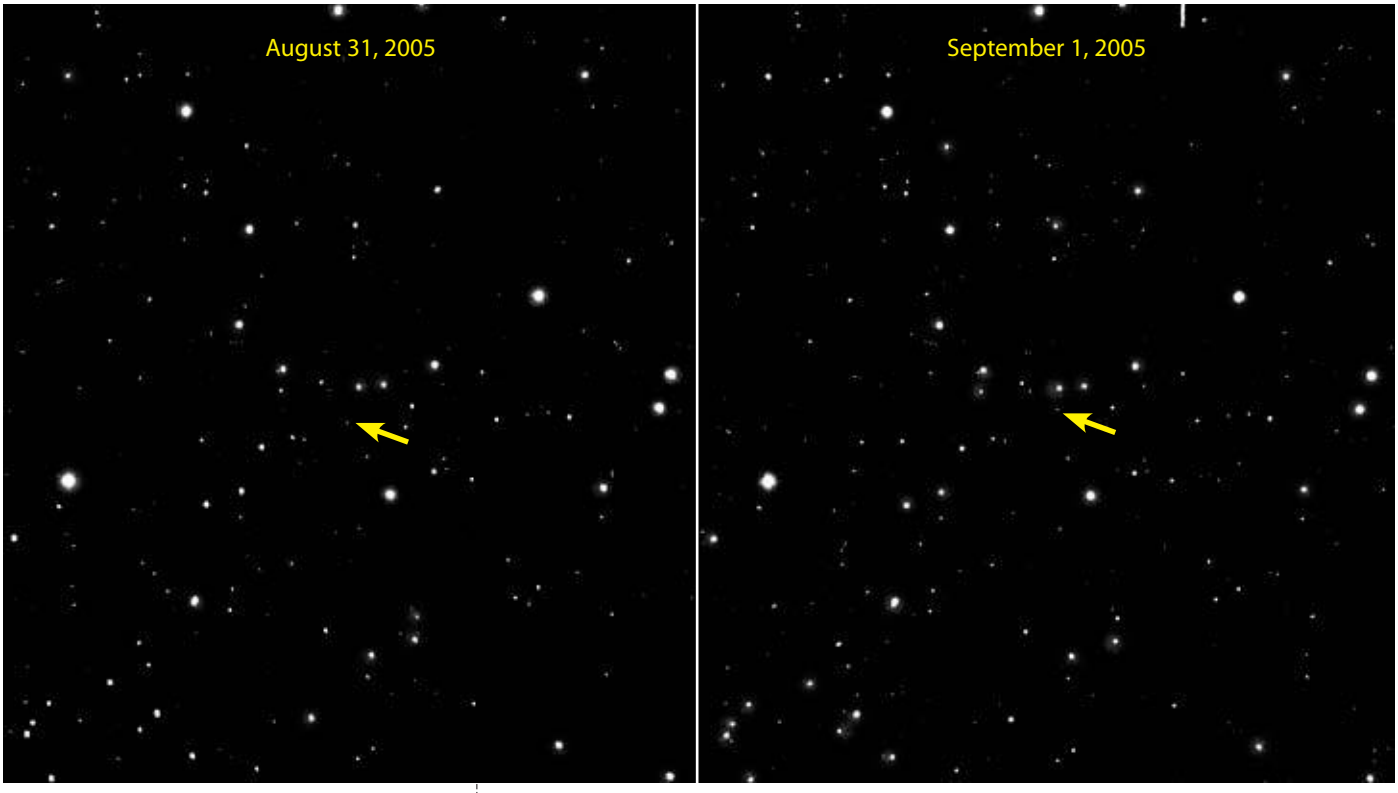


**2003 $UB_{313}$** (14-inch Celestron Schmidt-Cassegrain telescope at f/11, SBIG STL1001E CCD camera, 4-minute unfiltered exposures, taken August 31 and September 1, 2005, each at 10 P.M. PDT) /// **ALLEN HWANG, LOMA LINDA, CALIFORNIA**

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## The tenth planet

Caltech astronomer Michael Brown announced July 29, 2005, that his team had discovered a new planet both larger and more distant than Pluto. The object — dubbed 2003 $UB_{313}$ — is the farthest directly observed body in the solar system and the fourth brightest Kuiper Belt object. 2003 $UB_{313}$ now lies 97 astronomical units (AU) from the Sun — more than 9 billion miles (14.5 billion kilometers) — and has reached the farthest part of its 560-year orbit. About 280 years from now, it will reach its closest point to the Sun, at a distance of 38 AU (about 3.5 billion miles, or 5.6 billion km). The images above show the new planet's motion on consecutive nights.

**THE MOON AND VENUS** meet many times during the year, but because their evening get-togethers are easiest to see, most people notice those mo t. (Olympus OM-1 35mm camer , Z iko 40–150mm zoom lens at f/3.5 and set to 40mm, 4-second tripod-mounted exposure on ISO 200 film, taken August 8, 2005, at 21h11m UT) /// **MILJENKO KIS, PRELOG, CROATIA**

**GLOBULAR CLUSTER M2** in Aquarius is a southern-sky showpiece for Northern Hemisphere observers. (8-inch Celestron Schmidt-Cassegrain telescope at f/10, Starlight Xpress MX-916 CCD camera, RGB image with exposures of 16, 16, and 20 minutes, respectively) /// **AL KELLY, FRIENDSWOOD, TEXAS**

**THE IRIS NEBULA (NGC 7023)** is a beautiful reflection nebula with lots of dust. (14.5-inch RC Optical Systems Ritchey-Chrétien reflector at f/7.9, SBIG ST-11000 CCD camera, LRGB image with exposures of 100, 60, 60, and 60 minutes, respectively) /// **TONY AND DAPHNE HALLAS, FORESTHILL, CALIFORNIA**

**OPEN CLUSTER NGC 7380** in Cepheus may not be the first thing you notice in this image. The cluster is involved with the emission nebula Sharpless 2–142; its striking red color shows up well in time-exposure images. When you view this area through a telescope, however, the star cluster dominates the view. (20-inch homebuilt Newtonian reflector, IMG6303E CCD camera, Hα/RGB image, with exposures of 120, 50, 50, and 50 minutes, respectively) /// **BRIAN LULA, PRINCETON, MASSACHUSETTS**

Send sour photos to: *ASTRO OMY* Reader gallery, P. O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com.
Please include your full name, datT an location of image, and complete photo data: telescope, camera,ifilu, and exposure information.

**BARRED SPIRAL GALAXY M61,** 60 million light-years away in Virgo, ranks as one of the brightest members of the Virgo cluster of galaxm . M61 is comparable in size to the Milky Way, about 100,000 light- ears acr ss. M61 has star-forming regions (pink areas) you can see through a large telescope. (20-inch RC Optical Systems Ritchey-Chrétien telescope at f/8.4, SBIG ST-10XME CCD camera, LRGB image with exposures of 90, 2 N 2 and 20 min t s resp ctively) /// **ADAM BLOCK/NOAO/AURA/NSF**

**VAN DEN BERGH 93** in Monoceros the Unicorn is a bright nebula where curtains of gas and dust dram tic9lly open to reveal the inner region of this star-forming area. SAO 152320 is the bright star at center. VdB 93 is a portion of the much larger Gum 1 Nebula and lies 4,000 light-years away. (20-inch RC Optical Systems Ritchey-Chrétien telescope at f/5.5, SBIG ST-10XME CCD camera, LRGB image with exposur s of 100, 0, 20, and 20 minutes, respectively; data taken on two nights. Color data courtesy of Fred Calvert.) /// **BILL UMINSKI AND CYNDI KRISTOPEIT/ADAM BLOCK/NOAO/AURA/NSF**

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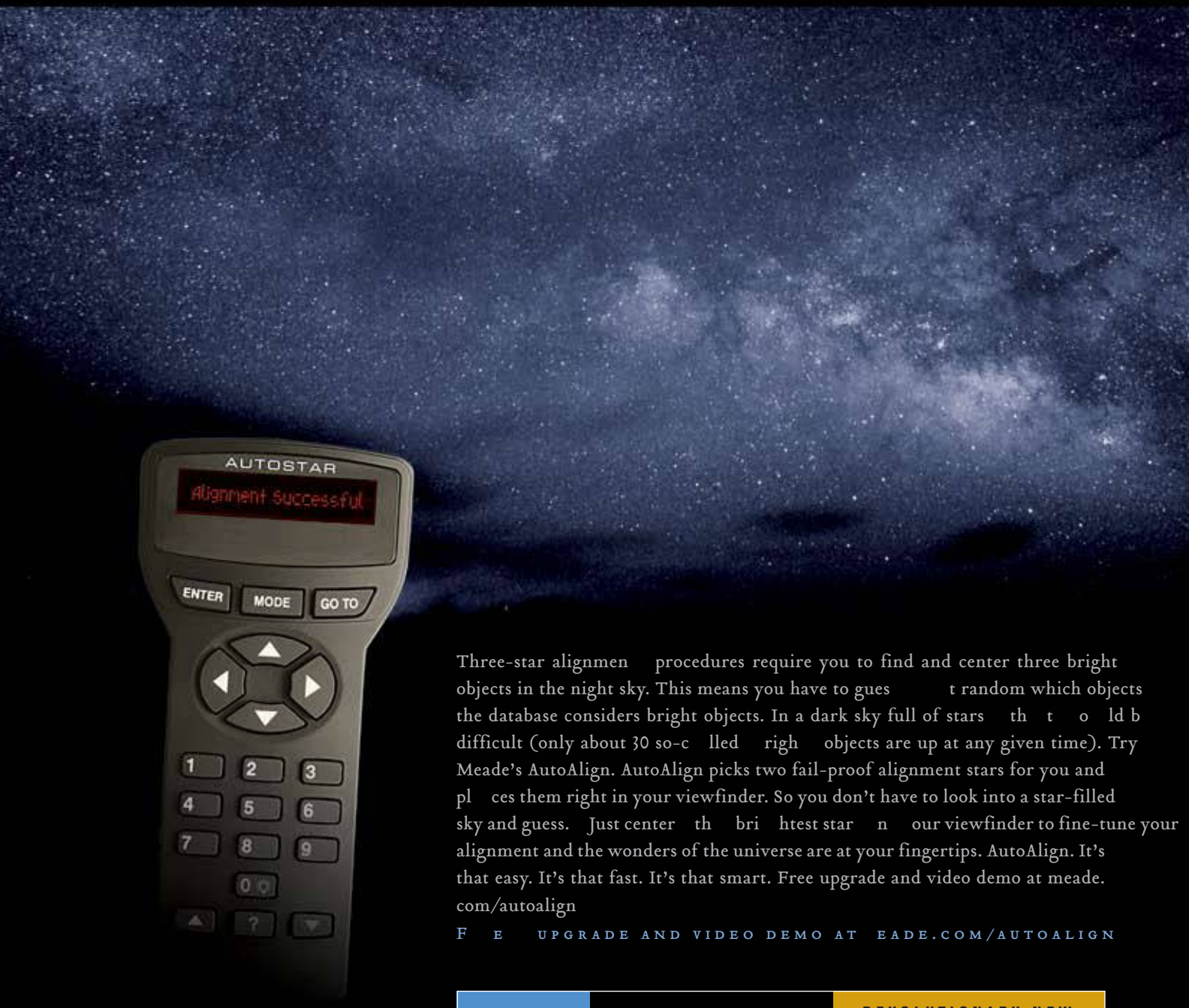


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